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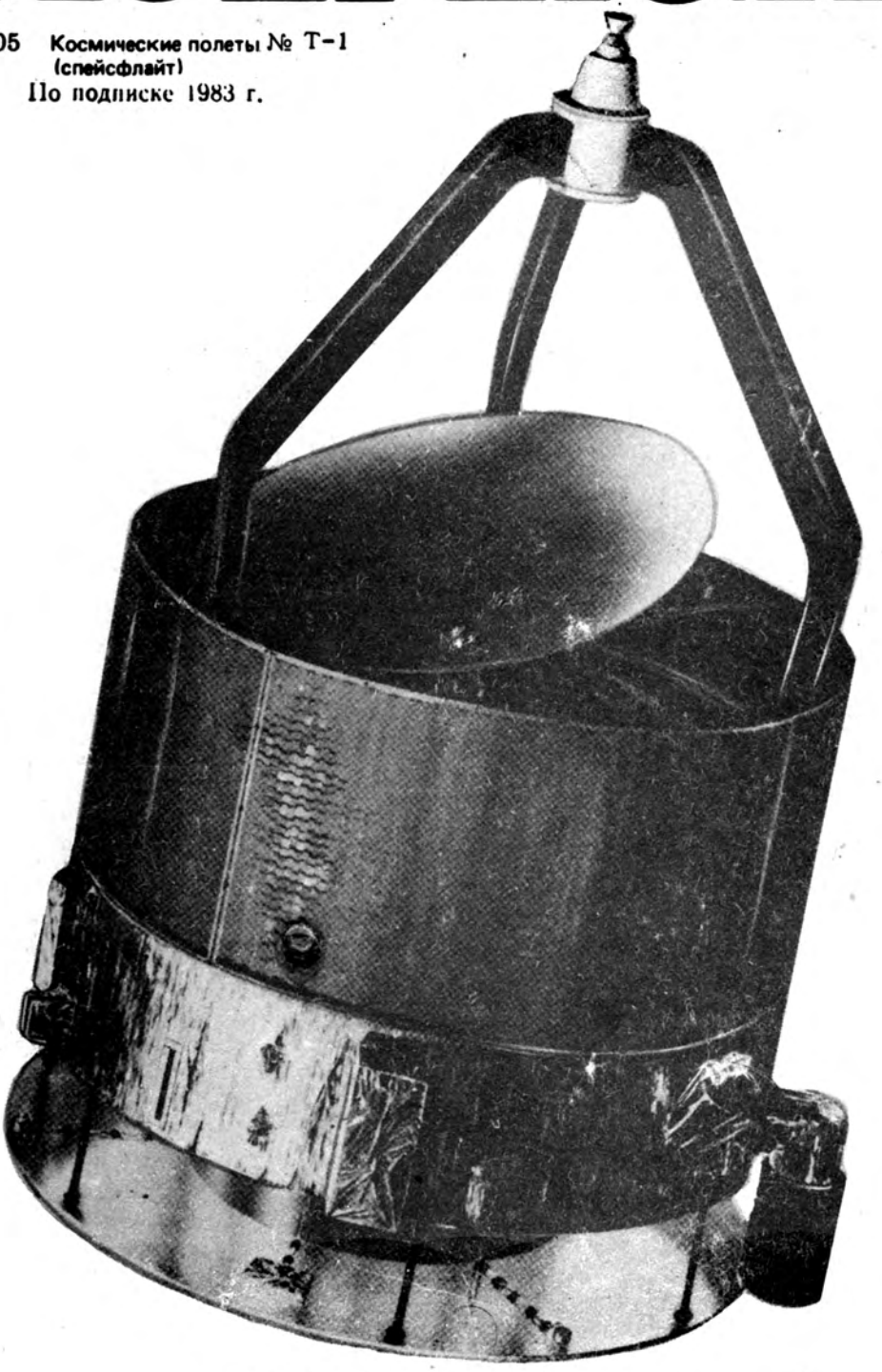

OUR 50th ANNIVERSARY YEAR

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SPACEFLIGHT

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CONTENTS

2 **An Expedition to Mars**
R. L. Staehle

7 **Space Report**

13 **One Eye at the Telescope**
Dr. W. I. McLaughlin

16 **Space Communications**

18 **Space Debris – A Growing Hazard**

20 **Astronauts for the Shuttle**
Curtis Peebles

24 **The End of an Era**

26 **Orbiting Quarantine Facility**
Petter Hesselberg

28 **Salyut Mission Report**
Neville Kidger

30 **John Young – One Man's Conquest of Space (Part 2)**
David J. Shayler

33 **Research from Soviet Satellites**
Joel Powell

36 **The Titan Launch Vehicle Family**
J. G. Davies

39 **Satellite Digest – 160**
R. D. Christy

40 **Society News**

42 **Correspondence**

45 **Book Notices**

British Aerospace Space and Communications Division are the prime contractors for the development and production of the Giotto probe to intercept Halley's Comet in 1986. Giotto's instruments will provide data on the chemical composition of the coma region surrounding the nucleus, and of the comet's tail. A camera will take colour photographs of the nucleus; measurements will also be made of the magnetic field. In this artist's impression, Giotto is seen speeding in towards the nucleus.

British Aerospace

MILESTONES

September 1982

20 The Progress 15 supply craft docks with the Salyut 7 space station, still occupied by the first long-stay crew, Berezevoi and Lebedev. The crew were to remain aboard for four months initially but it now appears that target has been raised to six months, and possibly higher.

21 Shuttle Orbiter *Columbia* is transported to launch pad 39A at the Kennedy Space Center for its fifth orbital flight. One thermal tile remains to be attached (273 were removed after the last mission, 170 of them damaged during the flight). A mock countdown with all four astronauts aboard will take place on the 24th and the two communications satellites will be installed in the cargo bay during 18 October. After STS-5, *Columbia* will be taken out of service to allow modifications in time for the Spacelab mission next September.

22 It is reported that US spending on military space projects will be raised to $11,000 million by 1987. NASA's budget for fiscal year 1982 is $5,500 M (military: $6,400 M); for FY 1983 $6,100 M (military: $8,500 M) is being sought.

28 The fifth Intelsat 5 communications satellite is launched by Atlas Centaur from the Kennedy Space Center. It carries an additional maritime communications subsystem with a 30 voice-channel capacity to be leased to the International Maritime Satellite Organization. Inmarsat recently lost its Marecs-B satellite in the Ariane L5 launch failure.

29 It is announced that NASA and Canada have agreed to the selection of several (up to five) Canadians for training as Mission Specialists for Space Shuttle missions. Training would take several years.

October 1982

4 The 25th anniversary of the launching of Sputnik 1, the first artificial satellite.

11 The crew for the 10th Shuttle orbital mission, an all-military flight carrying the Teal Ruby satellite (see November's *Spaceflight*, p. 408), is announced as Tom Mattingly (Cdr.), Loren Shriver (Plt.), and Ellison Onizuka and James Buchli (Mission Specialists). Mattingly commanded the STS-4 mission last summer. STS-10 launch date is 14 December 1983.

12 The Soviet Union launch three satellites (Cosmos 1413–1415) with the same booster to begin the formation of a global navigation satellite system.

12 The two communications satellites, SBS and Anik C3, are transported to the launch pad for installation in Shuttle Orbiter *Columbia's* cargo bay on 18 October for the STS-5 mission. They will be the first commercial satellites carried.

14 The local Cape Canaveral *Today* newspaper reports that the Astrotech International company will build a satellite processing facility to compete with NASA's own. The space agency presently charges almost $2 million for every satellite they prepare for launch (adding boost motors, testing mechanical systems, etc). NASA appears to welcome the competition because it shifts work away from their hard-pressed facilities.

SPACE '82 PRESENTATION TO THE SOCIETY

The Society's Space '82 conference in Brighton on 12–14 November proved to be a resounding success. Well over 300 delegates were treated to a wide-ranging tour of space activities by a host of space experts; we hope to bring members a full account in a future issue of *Spaceflight*. A particularly pleasant surprise was the presentation of a special plaque by NASA in recognition of the Society's pioneering work over the years. The plaque included British and US flags carried aboard Space Shuttle *Columbia* during its third orbital trip last March with astronauts Jack Lousma and Gordon Fullerton. It is a piece of space history which the Society is proud to possess.

AN EXPEDITION TO MARS

By Robert L. Staehle*

When sending men to Mars why not use solar sails to ease the transportation burdens? That is the idea proposed in this design article from BIS member Robert Staehle. He presents a scheme for a manned trip to Mars using existing technology and Shuttle-era potential.

This article highlights the main concepts. For interested readers, a detailed analysis appears in the July 1982 issue of the "Space Technology" *JBIS.*

Introduction

Whichever method is chosen for the first manned expedition to Mars, the hardware actually employed will differ considerably from that proposed in the original designs. This paper is an illustration of one very preliminary concept for sending the first humans to Mars. The intention is to show the present position of Shuttle-era technology in relation to a realistic Mars expedition, the magnitude of effort required, and to introduce the concepts of solar sailing, aerocapture and assembly of equipment cached in Mars orbit into the discussion of Mars expeditions.

Technical objectives for the expedition have been set so that realistic systems requirements and equipment masses can be estimated. Each mission segment has a minimum crew of two for safety reasons. With a crew to maintain an Earth-return spacecraft and a lander crew for exploration and sample return, there is a minimum crew of four. So that the crew of a disabled craft may join the crew of the other requires at least two independent spacecraft, resulting in a total expedition crew of eight.

By minimising the logistical burdens of supporting such a mission, mass estimates can be made for comparison with the capabilities of the Heavy Lift Vehicle [1]. Existing operations in Earth orbit unrelated to Mars exploration, such as a low Earth orbit Space Operations Center (SOC) [2], are assumed. Astrodynamics calculations assume the 1988 Mars opportunity as an example even though under the present pace of US space activity this date is certainly too early.

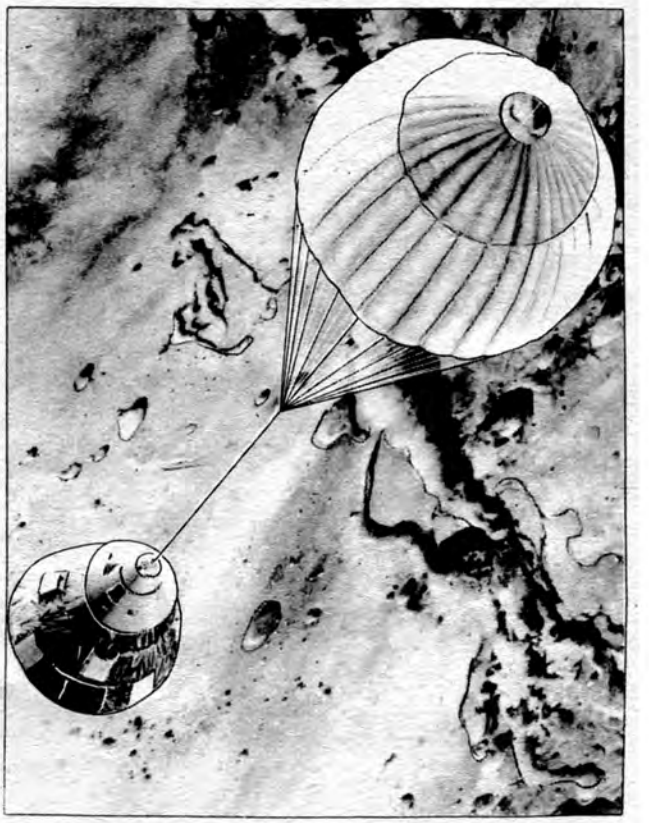
A modest improvement in life support technology is assumed incorporating semi-closed water and oxygen loops but without food regeneration.

The Mission Profile

Mission operations begin in low Earth orbit (LEO) with Shuttle-era Delivery Configured Orbiters (DCO) carrying up the Solar Sail Cargo Vessels (SSCV), followed by payload modules mated to each of 14 SSCVs in LEO. A jettisonable LOX/LH_2 boost stage carries the SSCVs with their payloads to a 2000 km circular orbit to avoid aerodynamic drag. The sails then deploy and slowly spiral out of Earth orbit on their way to Mars.

The SSCV are to carry everything required by the crews after they reach Mars [3, 4]. Telemetric monitoring is used to check the cargoes once in Mars storage orbits before the crews leave Earth.

While the trans Mars flight of the SSCV is in progress, Shuttles and DCO carry up the two Trans Mars Injection Assembly (TMIA) structures to the vicinity of the SOC. Additional launches carry up the two flyby Mars Transport Craft (MTC) and the two Mars Aerocapture Vehicles (MAV).



Artist's concept of Lander during parachute phase of descent to Martian surface. Viking descent propulsion requirements were scaled to Lander payload for propellant tank and engine sizing. Similarity to Apollo hardware is anticipated, as seen in the third stage of the Ascent Vehicle. Lander base diameter is limited by the need to carry it to Earth orbit while attached upside down to the aft cargo area of a modified Shuttle External Tank

Paul Hudson © 1982. Reproduced with permission.

The crews arrive with normal SOC resupply flights. A crew of four boards each assembled complex, consisting of the MAV, MTC, TMIA and associated LOX and LH_2 tankage.

Each of the expeditionary crews rides in a one-way MTC for the boost and cruise phases to Mars. The TMIA that provides the initial impulse is jettisoned after burnout. Just before arrival at the planet each crew enters its own MAV for attaining Mars orbit [5]. The two biconic MAVs, entering the upper atmosphere nose-first and nose-up with the crew upright, decelerate through the atmosphere and then slip back into orbit to rendezvous with the SSCV [6]. The MAV are actively manoeuvred during their single pass through the atmosphere and they dock base-first with waiting equipment in orbit [7].

Since a stay time of one and a half to two years is typically required at Mars before a suitable return opportunity occurs, a Mars Orbit Station (MOS) is assembled into a simple rotating structure. It is located in a 3000 km circular orbit selected for its accessibility to solar sails (lower orbits introduce atmospheric drag and sail-turning rate problems). Consisting of two separate ERV modules and a hub module, the MOS provides artificial Mars-level gravity to acclimatise the lander crews and to maintain the health of the orbiting crews.

* *Condensed by Henry Hoff, FBIS, from a presentation made by the author at "The Case for Mars Conference" in Boulder, Colorado in April 1981.*

TABLE 1. Vehicle Summary

SOC: Space Operations Center, a permanent space station in low Earth orbit.

DCO: Delivery Configured Orbiter, a development of the Shuttle Orbiter for carrying cargo into low Earth orbit.

SSCV: Solar Sail-Cargo Vehicles, for taking equipment to Mars to await crews.

TMIA: Trans Mars Injection Assembly, carries Shuttle engines to send expedition to Mars from Earth orbit.

MTC: Mars Transport Craft, occupied by crew for trip to Mars. Flies past Mars, releases MAV with crew aboard.

MAV: Mars Aerocapture Vehicle, carries crew into Mars orbit, braking through atmosphere. Docks with waiting vehicles.

LT: Lander Tankers, carry propellants for Mars Landers.

EEV: Earth Entry Vehicles, carried by ERV, final crew transport.

ERV: Earth Return Vehicles, formed from MOS and provision modules. Flies past Earth and releases EEV.

MOS: Mars Orbit Station, small space station to accommodate crew during long Mars stay. Sent to Mars before crew.

ML: Mars Lander.

Note that the LT, ML, MOS and ERV vehicles are sent into Mars orbit before the crews.

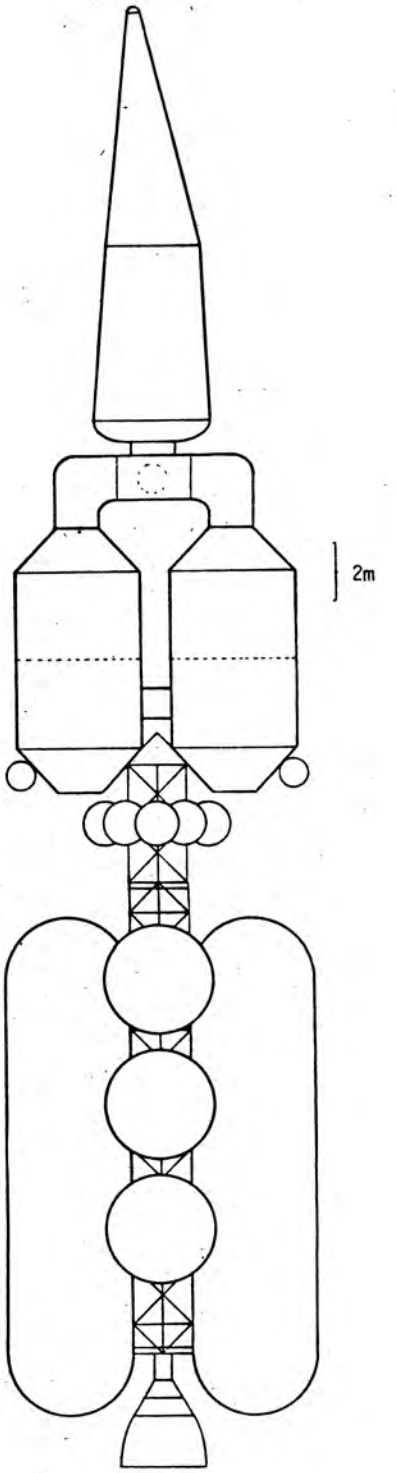
The Mars Landers (ML) are assembled and fuelled from the two Lander Tankers (LT), each carried to Mars aboard an SSCV. The ML are taken to Mars without propellant to keep the SSCV size to a minimum. With Earth-based assistance, the crews check the ML out, load them with propellants and prepare them for use. Limited simulations aboard the landers are used to refresh the skills of the crews. Final landing site validation is carried out, as on Viking, by remote sensing.

After separation from the MOS, each lander fires a Descent Orbit Insertion (DOI) engine. After this burn the DOI engine and propellant tanks are jettisoned. Atmospheric entry and deceleration is followed by parachute braking, heatshield jettison and powered terminal descent. The throttleable terminal descent engines are controlled by the crew and onboard computer.

After a month or more on the surface, a three-stage ascent vehicle using (essentially) Shuttle Orbital Maneuvering System (OMS) engines carries the samples and crew, housed in a somewhat smaller Apollo-like command module minus heat shield, back into orbit for rendezvous and docking with the MOS.

While sorties to Phobos and Deimos are possibilities, they require more propellant or equipment than presently included. They offer exciting targets and are not overly difficult to reach from the MOS, perhaps by using one of the MAV. With appropriate equipment, oxygen can probably be extracted from their regoliths. Without a great deal more research, including on-site testing (probably very difficult without people present), it seems imprudent to stake the safety of crew return on locally manufactured propellants. This initial expedition could set up and test a propellant plant for use by later missions. Such a plant would obviate the need for up to three SSCV return provision payloads and one LT.

Before Trans Earth Injection (TEI), the MOS is despun and disassembled. The two MOS Spacelab-derived habitability



Major elements of the Trans-Mars Injection Configuration are, from top to bottom, Mars Aerocapture Vehicle, Mars Transport Craft, and Trans-Mars Injection Assembly. TMIA and MAV are shown in side view, with the MTC rotated to a top view for clarity. MAV separates from MTC at base of blunt end, entering atmosphere nose-first with a high angle attack. MTC separates from TMIA at double line aft of small spherical midcourse propellant tanks. Life support consumables are contained in tanks on the aft cones of Spacelab habitability modules; only two representative tanks are shown. Two midcourse engines (from the Shuttle Orbital Manoeuvring System) are not shown at the aft end of the MTC, with their nozzles nested in the forward end of the TMIA structure. The TMIA drops off after the brief trans-Mars injection burn out of Earth orbit leaving the MTC and MAV in the Mars cruise configuration.

modules form the core of the two Earth Return Vehicles (ERV). Return provision modules cached in orbit are retrieved and attached to complete the two ERV. Like the MTC, the ERV, which are structurally similar to the MTC, do not enter Earth orbit [8]. Just before Earth flyby, the crews board their Earth Entry Vehicles (EEVs), similar to the Apollo command module, for a direct entry and landing or a rendezvous with the SOC for quarantine and eventual Shuttle return to Earth.

Shuttles and Delivery Configured Orbiters (DCO)

The Space Transportation System with expected improvements such as the DCO, is assumed to be the sole terrestrial launch vehicle system [9].

Of a total of 53 Shuttle launches required, 42 assume a DCO. The DCO is a Shuttle stripped-down for a one-day payload delivery mission. The assumed maximum payload is 38,500 kg, with approximately 37,400 kg of that as useful payload in addition to appropriate adapters, attach fittings and safety margins.

The required launches take place over a four year period, and would presumably place only a modest burden on mid-1990's space transportation systems. A total of 1.6 million kg is launched by the STS to support the mission with approximately 10 per cent of additional payload allocated to airborne support equipment.

Fourteen of the DCO payloads are the SSCV. An expendable Centaur-derived boost stage is mated to each SSCV before launch, with the combination making up a single DCO payload. Each boost stage contains its full 3000 kg load of LH_2 and 9600 kg of a total 17,700 kg of required LOX at the time of DCO launch. The additional 113 t of LOX for the 14 SSCV boost stages is taken on when the payloads from the SOC assembly area are mated. This LOX is brought to the SOC by four DCO tanker flights.

A total of five launches are required to transport the two MTC and their MAV. The TMI propellant tanks, each sized for a single Shuttle launch, require another eight launches per MTC. The LH_2 tanks are launched within a few days of Earth departure to reduce the boil-off penalty. All MTC equipment and propellants are launched to the SOC for assembly. The TMIA structure and engines for the MTC are carried up on another flight.

If a circular conic lander is used, it can probably be carried into orbit beneath the shuttle external tank on a Shuttle launch [10]. The tank is 8.2 m in diameter and can probably accommodate payloads up to 1 m larger.

The Solar Sail Cargo Vessels (SSCV)

The SSCV are conceptually similar to the World Space Foundation's Solar Sail Engineering Development Mission, but the structure to support the large sails is different [11, 12]. The 2 km square area is probably near the limit for ground-manufactured sails for deployment in orbit [13]. The SSCV use centre-of-pressure shift control. Payloads are carried at the centre where major structural elements are joined. The sails are made from 2.5 μm-thick Kapton, coated with aluminium on one or both sides.

The SSCV collectively carry over 400 t of equipment and supplies, with return provisions and propellant making up the largest fraction. A redundancy factor of 4/3 is used for return propellant tanks in case of leakage. Three tanks of each propellant (nitrogen tetroxide and monomethyl hydrazine) are required per Earth Return Vehicle, but four are sent.

The Trans-Mars Injection Assembly (TMIA)

Three major elements are joined in low Earth orbit for the TMIA: LH_2 and LOX propellant tanks; the thrust structure; and two modified Space Shuttle Main Engines (SSME) with associated controls, plumbing, etc. Only one SSME is required for injection into the Mars trajectory, but the second is included in case of premature shutdown. The SSME are operated

TABLE 2. 1988 Mission Chronology

1984 March	Begin launching SSCV's, cargo
1988 January	Begin assembling MTC
1988 July 4	* Trans-Mars injection MTC, $C_3 = 11.5$ km^2/se
1989 January 13	Arrive Mars, capture $V_\infty = 2.74$ km/sec
1989 June	Land on Mars
1989 July +	Return to Mars orbit
1989 November +/-	Survey Phobos, Deimos (not in analysis)
1990 July 14	Trans-Earth injection, $V_\infty = 3.5$ km/sec
1991 April 14	Splashdown

* Trajectory information supplied by Gerald C. Snyder, JPL.

TABLE 3. Solar Sail Cargo Vessel Manifest

No.	Payload	Payload Mass (kg)
1	MOS-1	31,100
2	MOS-2	31,000
3	MOS-consumables	33,000
4	Hub	16,200
5	Return Provisions-1 (RP-1)	31,700
6	RP-2	31,700
7	RP-3	32,000
8	RP-4	29,700
9	RP-5	30,800
10	RP-6	30,900
11	ML-1	32,000
12	ML-2	32,000
13	LT-1	27,000
14	LT-2	27,000
		416,200

TABLE 4. Space Transportation System Manifest (not in chronological order)

Elements	Useful Payload Mass (kg)	Launches	Notes
MTC-TMI	33,600	1	DCO
MTC-1A, 2A	22,700	2	Volume
MTC-1B, 2B	29,600	2	DCO
MTC-1, 2 LH2	16,400	4	Volume
MTC-1, 2 LOX	32,400	12	DCO
ML-1, 2	32,000	2	Aft cargo
LT	27,000	2	
MOS-1A, 2A	29,100	2	DCO
MOS-1B	18,600	1	
MOS-2B + Hub	34,800	1	DCO
SSCV 1-14	34,700	14	DCO
RP-1,2	31,700	2	DCO
RP-3	32,000	1	DCO
RP-4	29,700	1	DCO
RP-5	30,800	1	DCO
RP-6	30,900	1	DCO
SSCV Boost LOX	32,400	4	DCO
Total	1,624,400	53	42 DCO

DCO = Delivery Configured Orbiter Volume = volume limited.

simultaneously under normal conditions. The TMIA includes six spherical LOX tanks and two cylindrical LH_2 tanks.

The energies required and the flight times, in this concept calculated for the 1988 opportunity, will vary considerably for different opportunities in the 1990's.

The Mars Transport Craft (MTC)

Each MTC consists of two pressurised Spacelab long modules, external stores, pressurised connecting tunnels and associated subsystems, and a Mars Aerocapture Vehicle docked axially to an airlock section of the forward tunnel. Spacelab- and Shuttle-derived subsystems are used for crew support.

Solar panels are sized to provide 2 kW per person at Mars aphelion with 12 per cent efficiency. The panels are either rolled up or, if rigid, scissor-folded back against the body during injection and midcourse manoeuvres. Internal batteries provide power during these periods. The SOC or a suitable tender vehicle provides power in low Earth orbit until a few hours before the injection burn.

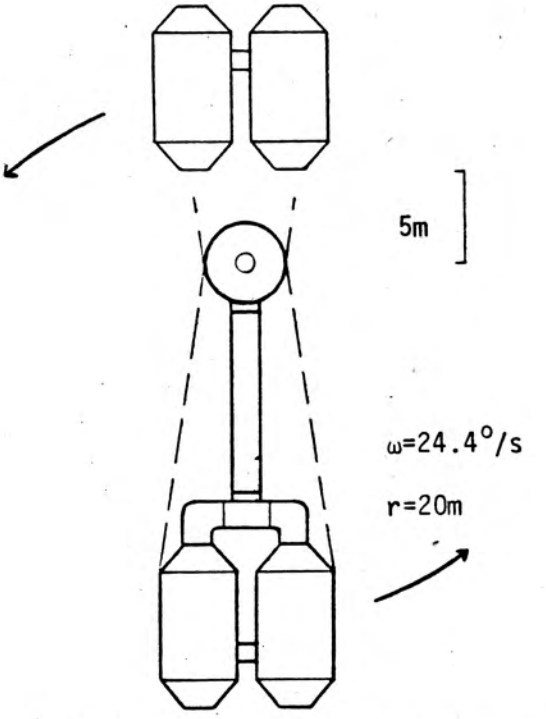
The Mars Aerocapture Vehicles (MAV)

The MAV are essentially an aerodynamic shell and an orbital propulsion systems wrapped around Apollo command & service module-like subsystem and crew accommodations. Once in Mars orbit they are used to adjust the MOS orbit and checkout and maintain the cargo cached by the SSCV. They are refuelled and reprovisioned from cached supplies.

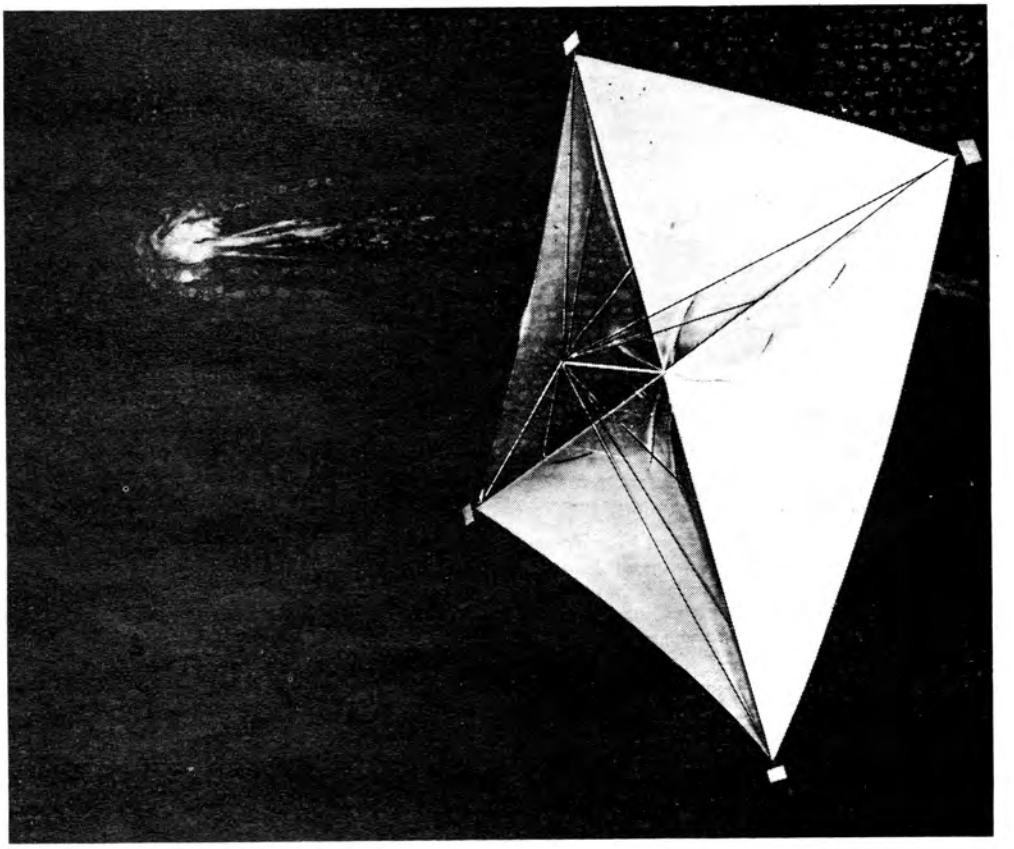
The Mars Orbital Station (MOS)

The rotating MOS provides, in the pressurized module, a g-level varying by 10 per cent over the 2 m height of a person.

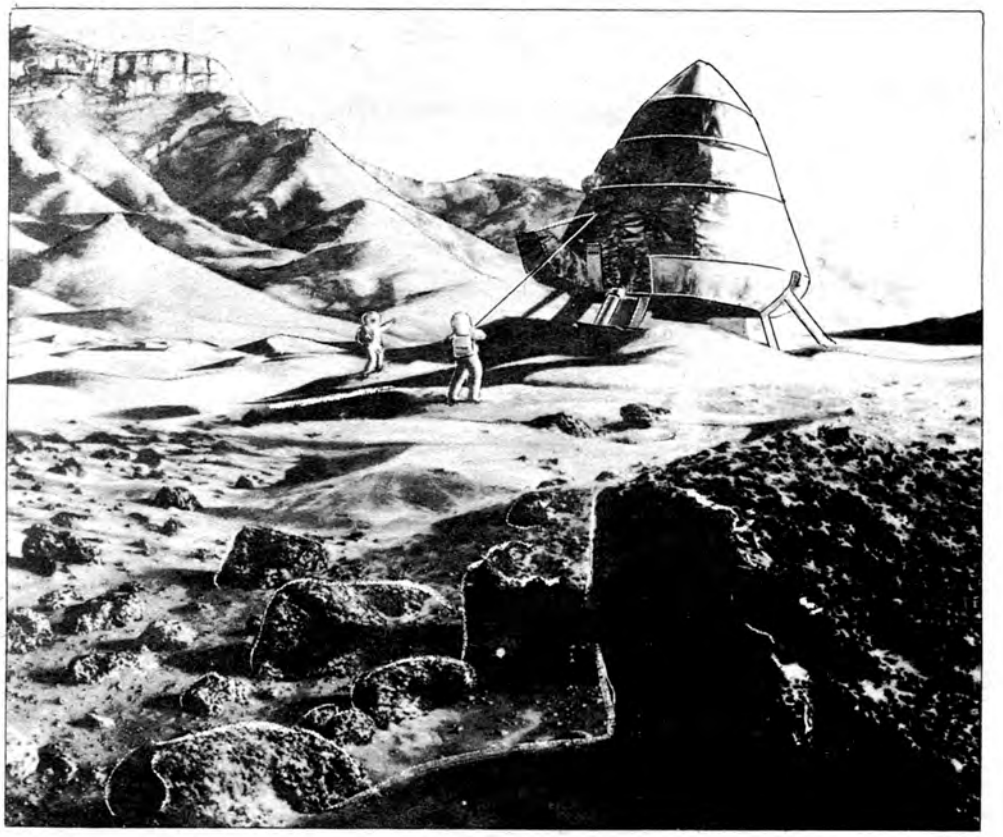
The hub, which serves as a MAV reprovisioner and as a base during MOS assembly, is a Spacelab-derived module with two radial and two axial docking ports. A damped tension structure connects the habitability modules with the hub, and inflatable tunnels allow unsuited crew transfer. The two hab-



The Mars Orbital Station spins to provide artificial Mars-level gravity for the crew during the long stay in orbit. This is especially important for the crewmembers who do not land, as they might otherwise experience three years in zero gravity, followed by a high-g reentry at the end of the mission (perhaps further experience with long duration missions in Earth orbit will show the provision of artificial gravity to be unnecessary).



NASA/JPL proposed a solar sail mission in the mid-1970's for rendezvous with Halley's Comet in 1986.



Initial activities on the Martian surface are shown in this artist's concept. The crew opens an equipment bay containing surface exploration equipment. Payload allowance was made in the design for a large roving laboratory, not yet unloaded.

Paul Hudson © 1982. Reproduced with permission.

itability modules are functionally independent. The spin axis is along the Sun line, and the solar panels shade the tunnels.

Despun docking ports hold the Mars Landers, while the MAV are docked radially and are not available while the MOS is spinning. There is enough propellant capacity in the hub for two complete spin/despin cycles and reserves.

The Mars Landers (ML)

No specific ML design is employed but mass estimates are based on previous studies. The heat shield mass is 2000 kg. The dry landed mass is estimated at 28,700 kg, including the crew, provisions and scientific equipment. Power is estimated at 2 kW per person.

N_2O_4/MMH is the propellant combination assumed for all mission propulsive burns after TMI and for all attitude control. Powered descent propulsion is scaled to the Viking thrust: weight and equivalent ΔV capability (258 m/sec), with a 1.2 safety factor added to the latter.

Each ascent vehicle carries the crew and up to 500 kg of samples.

Conclusions

The Space Transportation System forms the basis on which an initial Mars expedition may build. Transportation and life support are crucial areas of development before a Mars expedition can be carried out. Specifically, the assumption of large solar sails, aerocapture at Mars, a Delivery Configured Orbiter, and the aft cargo carrier capability are important in limiting the transportation requirements. The use of existing technologies and the introduction of a few key new technologies give confidence to mounting an initial Mars expedition for less than the cost of Apollo. [14]

For an initial Mars expedition with a small crew using basic techniques, it is important to use existing hardware and technologies in order to reduce costs, lead time and uncertainties. Although a minimum of STS launches does not necessarily imply minimum cost, the ultimate test between Mars expedition concepts of equal capability and safety is cost. Since a much more detailed analysis is required to arrive at a minimum, we are now at a point where we can argue over the minimum cost options for a Mars expedition, rather than simply arguing over its practicability.

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ASTEROID MISSION STUDIES

Asteroids provide a unique sample of the material which may hold significant clues to the way in which our Solar System was formed and evolved. RCA Astro-Electronics have been studying the feasibility of modifying their Tiros weather satellite to carry out a rendezvous mission with a near-Earth asteroid.

"Fully understanding the asteroids and their implications to Solar System physics requires an orderly study of several different types of bodies, by putting satellites in asteroid orbits," said Dr. Ronald Maehl, Manager of Scientific Programs for RCA Astro-Electronics. He noted that this approach would set the stage for multiple rendezvous missions with main belt asteroids between the orbits of Mars and Jupiter.

The three-month study, performed under contract from the Jet Propulsion Laboratory, examined a mission payload including imagers to record the size, shape and reflective characteristics of the asteroid, as well as other sophisticated instruments to define additional asteroid properties and the near-asteroid environment.

NEW SHUTTLE TANKS

A major milestone in the Space Shuttle programme was reached on 10 September when the first lightweight External Tank (LWT-1) was rolled out of the manufacturing plant at NASA's Michoud Assembly Facility in New Orleans.

The large brown External Tank carries the super-cold liquid oxygen and hydrogen propellants for the Space Shuttle Main Engines, and acts as the structural "backbone" of the Shuttle vehicle. The tank's three major components are an oxygen tank, a hydrogen tank and a collar-like intertank which connects the two propellant tanks and houses the entire structure's instrumentation.

At 71,000 lb (32,000 kg), LWT-1 is about 7,000 lb (3,200 kg) lighter than the External Tank used for the Shuttle's maiden flight in April 1981. The reduced weight will provide the Shuttle with extra payload-carrying capability almost equal to the weight reduction (because the Tank travels nearly all of the way into orbit).

According to James Odom, manager of the External Tank Project Office at the Marshall Space Flight Center, the reduction was accomplished by eliminating portions of stringers (structural stiffeners running the length of the hydrogen tank), using fewer stiffener rings and by modifying major frames in the hydrogen tank.

Also, large portions of the tank were milled differently to reduce thickness and weight; and the weight of the aft Solid Rocket Booster attachments was reduced by using a stronger, yet lighter and less expensive titanium alloy.

"Several hundred pounds was also eliminated by deleting an anti-geyser line," said Odom. This line acted as a built-in refrigeration system, keeping liquid oxygen at its super-cold temperature while filling the oxygen tank prior to launch. NASA officials decided to remove the line after assessing propellant loading data from ground tests and the first few Shuttle missions.

Although most of the Tank's alterations will not be apparent to the casual observer, one change is already obvious: 600 lb (270 kg) of white latex paint was eliminated from the outer skin before the third flight. After analysing data from the first mission, NASA officials determined that the thermal protection system would adequately protect the Tank without the paint.

After "rollout", the tank was loaded aboard a NASA barge for shipment to the Kennedy Space Center where it was to be prepared for the sixth mission.

ORBITING GOLD MINE

Perhaps NASA should consider training a security guard as an astronaut for future Space Shuttle missions. His job? - to protect the 456 lb (207 kg) of high-quality gold carried by the Orbiter in each flight. The only snag for a would-be robber, though, is that nearly all of the precious metal (worth upwards of $2 million) is deposited in microscopic layers on thermal insulation blankets in the cargo bay and on experiments. A 3 in (7.5 cm) cube of the stuff can be vaporised and spread on a full acre (4050 m²) of blanket.

The high cost has prompted NASA to search for a cheaper material and now they intend to equip the *Discovery* and *Atlantic* Orbiters with blankets using an acrylic film some 90% cheaper. Acrylic just doesn't seem as romantic, somehow . . .

INDIA'S SATELLITES

The failure of India's Insat-1A communications/meteorology satellite to respond to ground control has dealt a severe blow to that nation's ambitious space applications programme. Insat-1A has been plagued by recurring problems since its launch last April. The satellite finally ran out of fuel because of manoeuvres designed to deploy the jammed C-band antenna. Thus, Insat-1A has been written off for all practical purposes. With the standby Insat-1B scheduled for launch in July 1983, there will be a gap of less than a year in satellite coverage for communications, writes Gerald Borrowman.

India's next communications satellite project was planned to get off the ground in the early 1990's, after the 10-year span of the Insat twins had expired. One problem will be in finding a suitable parking slot for the new satellite so that its beam can cover the entire country. With overcrowding in space, Insat-1A had to be parked over Indonesia, which was not the ideal spot.

Guion Bluford has been named as one of the Mission Specialists astronauts for the STS-8 Shuttle mission next July. The flight will be commanded by Dick Truly who served as Pilot on *Columbia's* second orbital trip.

Meanwhile, data sent by India's second experimental satellite, Bhaskara-II, has proved extremely useful in meteorology, vegetation surveys and in other fields. The satellite has returned images that have been used in preparing land cover and land use maps of parts of West Bengal and Bihar. Maps showing permanent regions of snow and ice in the Bhagirthi – Alaknanda basin have also been prepared from satellite data. The microwave sensor was helpful in determining atmosphere water vapour, rainfall rates and sea surface winds.

SOLAR ARRAY EXPERIMENT

A 105 ft (32 m)-long experimental solar array has been successfully extended and retracted during initial testing in preparation for flight aboard the Space Shuttle in 1984.

The wing is part of NASA's Solar Array Flight Experiment, developed for NASA's Marshall Space Flight Center. The experiment is undergoing extensive testing by its manufacturer, Lockheed, before acceptance by the Marshall Center.

The flight experiment is helping to develop technology necessary for using solar arrays to produce large amounts of electrical power from sunlight in space. The additional power could significantly expand space-based mission operations by meeting the high energy, long term requirements of space experiments and space platforms.

One of the major objectives of the recent tests was to check the extension/retraction system that will deploy the wing from its packaged configuration aboard the Shuttle during the flight. During launch, the accordion-like array wing, 105 ft (32 m) long and 13.5 ft (4.1 m) wide, will be folded in the Orbiter's cargo bay in a package less than 4 in (10 cm) thick. Once on orbit, it will be extended to its full length and retracted several times to verify the structural and dynamic characteristics. A coilable, extension mast will provide the mechanism needed to extend, retract and hold the array in a planar configuration.

This solar array departs from rigid metal structures currently used on long-life spacecraft. Instead, it is made of lightweight, flexible plastic (Kapton) and contains wrap-around contact solar cells that are welded directly to the array blanket. This printed circuit approach eliminates heavy adhesives and allows greater flexibility during handling and during extension and retraction.

To minimise costs, the experiment will contain only one wing panel with live solar cells. By contrast, an array with all 84 panels populated with solar cells could convert energy from the Sun to produce 12.5 kilowatts of power. The experimental wing can provide 66 watts per kilogram compared with 20 watts per kilogram in present systems. With current high efficiency cells, up to 75 watts per kilogram are feasible using the same structural concepts.

MORE SPACE STATION STUDIES

NASA has reaffirmed its intense interest in establishing a permanent space station in the 1990's (see November's *Spaceflight*, p. 402) by contracting four leading aerospace companies to perform studies in addition to the eight studies requested earlier.

The firms selected were Boeing, Martin Marietta, TRW, and General Dynamics.

These new eight-month studies are intended to provide a thorough examination of specific potential missions that could be conducted by a station permanently in orbit.

With the success of the first Shuttle flights, NASA has begun a planning effort to define a space station, for consideration by the Administration and Congress as the next major initiative in space.

The Marshall Center recently invited the aerospace firms to propose how an early space station, one that might be in

Continued on p. 11

US COMET PROBE

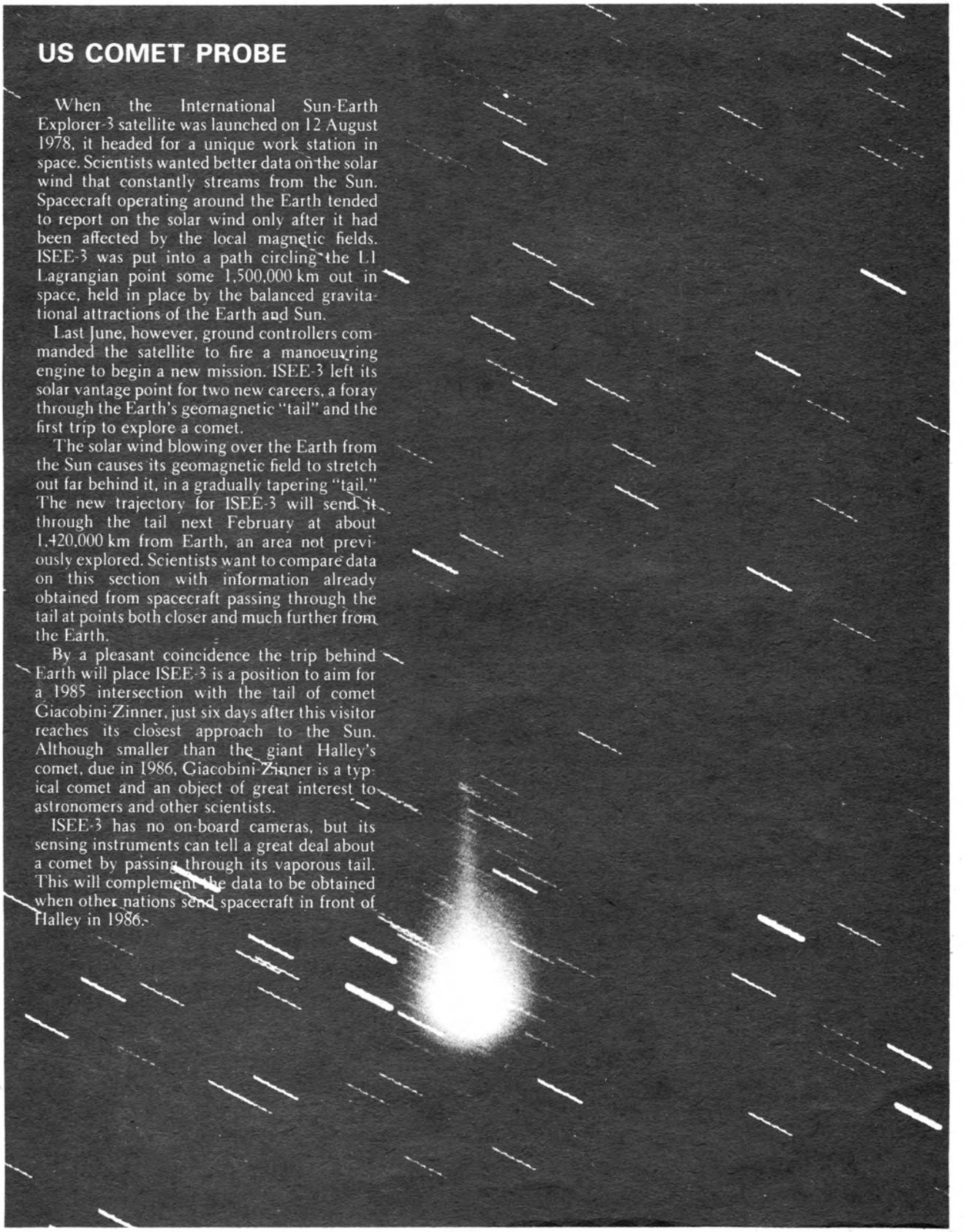
When the International Sun-Earth Explorer-3 satellite was launched on 12 August 1978, it headed for a unique work station in space. Scientists wanted better data on the solar wind that constantly streams from the Sun. Spacecraft operating around the Earth tended to report on the solar wind only after it had been affected by the local magnetic fields. ISEE-3 was put into a path circling the L1 Lagrangian point some 1,500,000 km out in space, held in place by the balanced gravitational attractions of the Earth and Sun.

Last June, however, ground controllers commanded the satellite to fire a manoeuvring engine to begin a new mission. ISEE-3 left its solar vantage point for two new careers, a foray through the Earth's geomagnetic "tail" and the first trip to explore a comet.

The solar wind blowing over the Earth from the Sun causes its geomagnetic field to stretch out far behind it, in a gradually tapering "tail." The new trajectory for ISEE-3 will send it through the tail next February at about 1,420,000 km from Earth, an area not previously explored. Scientists want to compare data on this section with information already obtained from spacecraft passing through the tail at points both closer and much further from the Earth.

By a pleasant coincidence the trip behind Earth will place ISEE-3 is a position to aim for a 1985 intersection with the tail of comet Giacobini-Zinner, just six days after this visitor reaches its closest approach to the Sun. Although smaller than the giant Halley's comet, due in 1986, Giacobini-Zinner is a typical comet and an object of great interest to astronomers and other scientists.

ISEE-3 has no on-board cameras, but its sensing instruments can tell a great deal about a comet by passing through its vaporous tail. This will complement the data to be obtained when other nations send spacecraft in front of Halley in 1986.



Comet Giacobini-Zinner: a short-period comet of the Jupiter family, with a period of about 6.5 years. It was discovered by Giacobini at Nice in late 1900, accidentally rediscovered in 1913 by Zinner. The return to perihelion in February 1979 was the 10th observed appearance. P/Giacobini-Zinner is the parent comet of the Draconid (Giacobinid) meteor stream; notable showers occurred in 1933 and 1946. The meteoroids are noteworthy for their very low density and fragility.

The photograph shows the comet in October 1959 with a half-degree tail, observed from the US Naval Observatory at Flagstaff in Arizona.

Courtesy of Prof. E. Roemer/US Navy

THE ASTRONAUTS OF STS-6

Paul Joseph Weitz

Paul Weitz was born in Erie, Pennsylvania on 25 July, 1932. He was educated in Pennsylvania and received a degree in aeronautical engineering from the state university in 1954. He entered the US Navy that same year and was awarded his wings in September 1956.

Between June 1962 and June 1964 Weitz attended the USN postgraduate school and was awarded a masters degree in aeronautical engineering. He retired from the USN in 1976.

Selected as one of 19 group 5 pilot astronauts in 1966, he was a member of the support crew for Apollo 12. He flew as Skylab 2 pilot in May and June 1973, spending 28 days in space and logging 2 hours 11 minutes in EVA outside the space station.

Weitz was assigned to Shuttle development in 1975, being concerned with crew station hardware and Earth resources studies. In 1977 he headed the design support group in the Astronaut Office at the Johnson Space Center and by April 1979 he was responsible for coordination of the technical effort in Shuttle development.

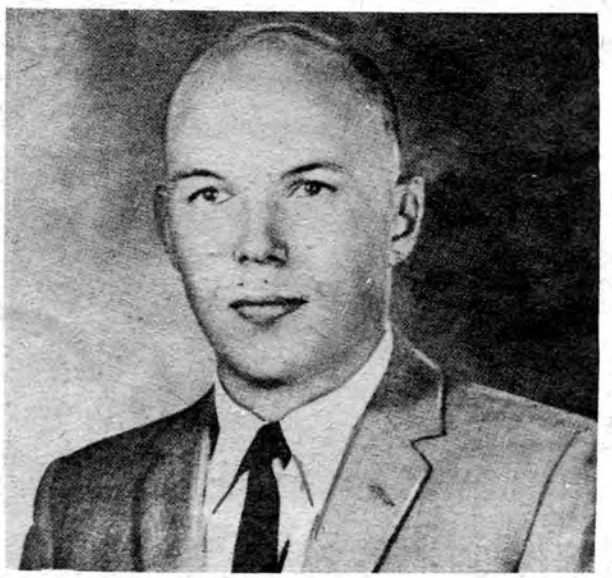
He was named as Commander of STS-6, the first flight of the second Orbiter, in December 1981.

Karol Joseph Bobko

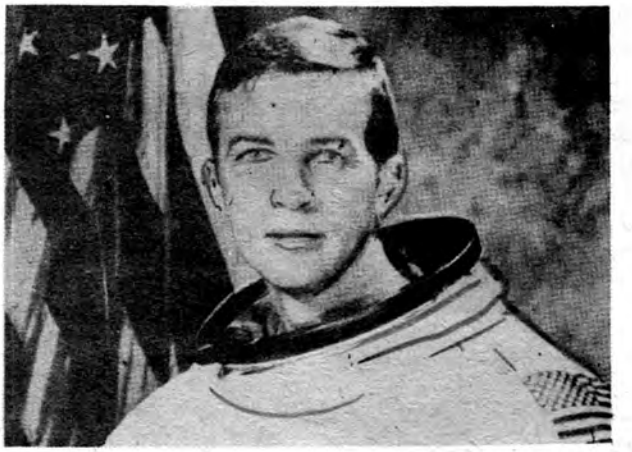
Karol Bobko was born in New York on 23 December 1937. He received a bachelor of science degree from the USAF Academy in 1959 and was awarded wings in 1960.

In 1965/66 he attended the Aerospace Research Pilots School at Edwards Air Force Base and was selected for the Manned Orbiting Laboratory project in June 1966. He transferred to NASA in August 1969.

In January 1973 Bobko was assigned to the Apollo Soyuz Test Project and was a support crew member until July 1975. He was assigned to the Shuttle landing test programme in 1976 and served alternately as CapCom and primary chase pilot. During the first weeks of 1979 he conducted ground tests and checkouts with *Columbia*. He was named as Pilot for STS-6 in December 1981.



Story Musgrave



Don Peterson

Donald Herod Peterson

Don Peterson was born on 22 October 1933 in Winona, Mississippi. He graduated from West Point with a bachelor of science degree in 1955 and in 1962 he obtained a masters degree in nuclear engineering from the Air Force Institute of Technology in Ohio. He was selected for the MOL programme in 1967, serving as astronaut flight member until its cancellation in 1969.

Selected as one of seven group 7 former MOL astronauts by NASA that same year, he was assigned as support astronaut for Apollo and acted as a CapCom for Apollo 16. He moved on to Shuttle development in 1975, being concerned with navigation, communications and tracking hardware, as well as reaction control and orbital manoeuvring hardware.

In April 1979 Peterson was a member of the Orbital Flight Test mission group of the Astronaut Office responsible for engineering support and safety assessment. He retired from the USAF in 1980 and was named as a Mission Specialist for STS-6 in December 1981.

Franklin Story Musgrave

Story Musgrave was born in Boston on 19 August 1935. He gained the following degrees between 1958 and 1979: B.Sc. in mathematics and statistics (1958); Masters in business administration and computer programming (1959); B.A. in chemistry (1960); Doctorate in medicine (1964); M.Sc. in physiology and biophysics (1966); and Doctorate in physiology/biophysics, with a minor in aeronautical engineering (1979).

Musgrave was selected for the astronaut programme in August 1967. He subsequently took part in the Skylab programme, serving as a backup for Skylabs 1 and 2 and as CapCom for Skylab 3. He was mission specialist for the first two Spacelab mission simulations in 1974 and 1976. In 1975 he participated in the development of Shuttle EVA equipment.

In addition to his astronaut duties, Musgrave has continued clinical and scientific training as a part-time surgeon and as a part-time professor of physiology and biophysics. He has written over 30 scientific papers, logged over 10,000 flying hours and made over 330 free fall parachute drops. He was named as a Mission Specialist for STS-6 in December 1981.

D.J. SHAYLER

SHUTTLE ORBITER "COLUMBIA": A BRIEF CHRONOLOGY

1976

Jun. 28	Start assembly crew module.
Sep. 13	Start assembly aft fuselage.
Dec. 13	Start assembly upper forward fuselage.

1977

Jan. 3	Start assembly vertical stabilizer.
Feb. 10	Mid fuselage delivered Rockwell plant, Palmdale, California.
Sep. 7	Lower fuselage delivered, Palmdale.
Nov. 4	Deliver aft fuselage, Palmdale.

1978

Jan. 10	Vertical stabiliser delivered, Palmdale.
Feb. 17	Crew module delivered, Palmdale.
Feb. 24	Body Flap delivered, Palmdale.
Mar. 6	Upper forward fuselage delivered, Palmdale.
Mar. 19	Aft payload bay doors delivered, Palmdale.
Apr. 28	Forward payload bay doors delivered, Palmdale.
May 26	Completed forward Reaction Control System structure and mating of upper forward fuselage.
Jly. 7	Completion of mating forward and aft payload bay doors.
Aug. 11	Completion mating Reaction Control System, Palmdale.

1979

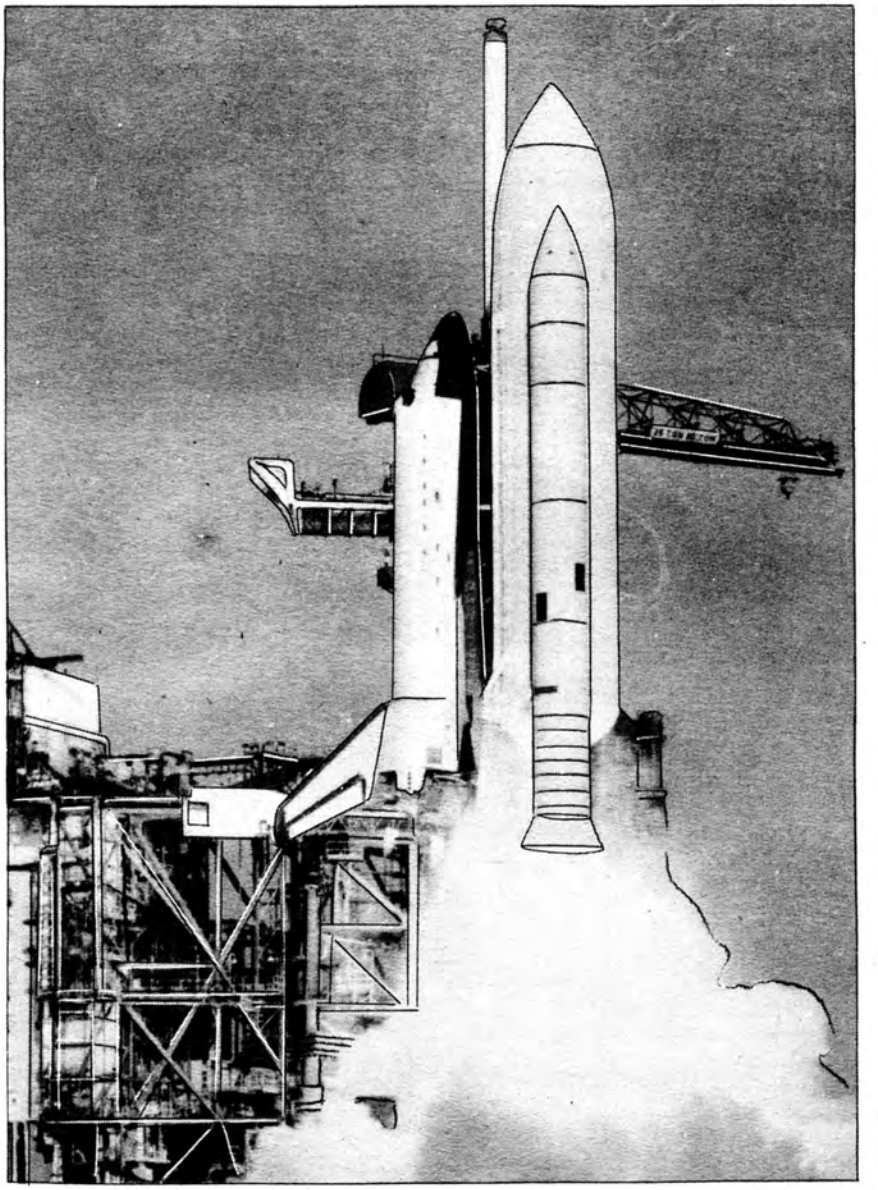
Jan. 25	Orbiter 102 received official name of *Columbia*
Feb. 16	Airlock delivered, Palmdale.
Mar. 8	Final NASA acceptance, Palmdale. Transported overland from Palmdale to NASA's Dryden Flight Research Center.
Mar. 20-24	Ferry flight to Kennedy Space Center.

1980

Aug. 3	Completion of main engine installation.
Oct. 9-10	Removal of one main engine for modification. Replaced Nov. 8-10.
Oct. 11-12	Installation of Orbital Manoeuvring/Reaction Control Systems.
Nov. 16	Completion of installation of thermal protection system.
Nov. 24	Transfer from processing facility to VAB.
Nov. 26	Mated to ET and SRB's.
Dec. 29	Transferred to launch pad.

1981

Feb. 20	20 second test firing of main engines.
Apr. 10	Launch of STS-1 cancelled due to APU failure.
Apr. 12-14	Launch, flight and landing of STS-1.
Apr. 20-21	Ferry flight from California to Kennedy Space Center.



Jly. 1st wk.	OSTA-1 experiment package installed.
Aug. 10	Transferred to VAB.
Aug. 12	*Columbia*/ET/SRB mating completed.
Aug. 31	Transfer to pad for STS-2.
Sep. 22	Propellant spill damages tiles.
Sep. 29	Tile rebonding began.
Nov. 4	Launch cancelled 31 seconds short of lift off.
Nov. 12-14	Launch, flight of STS-2, landing. Mission cut from 5 days.
Nov. 25-26	Ferry flight back to Kennedy Space Center.

1982

Jan. 10	OSS 1 payload installed.
Feb. 3	Transferred to VAB.
Feb. 4	Mated to ET and SRBs for STS-3.
Feb. 16	Transferred to launch pad.
Mar. 22-30	Launch, flight and landing at White Sands.
Apr. 5-6	Ferry flight to Kennedy Space Center.
May 17	Transferred to VAB.
May 20	Mated with ET and SRBs for STS-4.
May 26	Transferred to pad.
Jun. 6	Military payload installed on pad.
Jun. 27-Jly. 4	Launch, flight and landing.
Jly. 15	Ferry flight to Kennedy Space Center.

D.J. SHAYLER

Continued from p. 8

orbit by 1990, could be used as a test facility to develop certain mission capabilities for a later, operational space station near the year 2000. Each of the four contracts addresses a particular area in which such an operational manned facility would play an active role.

One study area, to be examined by Boeing, will look at the role of a manned space station with regard to building large structures in orbit, such as huge communications antennae. A second study area, to be pursued by both Martin Marietta and TRW, will deal with the servicing and maintaining of satellites from the manned facility. Finally a third study area, to be investigated by General Dynamics, will examine the relationship of the space station with an "orbit transfer vehicle," a space vehicle for moving payloads from lower to higher orbits. The transfer vehicle could be kept in space and serviced by a manned facility.

"In brief, these studies assume that an early space station will be in orbit by 1990," said William R. Marshall, director of Program Development at the Marshall Center. "Given that premise, the studies will then suggest what kinds of experimental operations would be performed with such an early space station so that we can evolve to a fully operational station by the turn of the century."

The Marshall Center has been studying large space structures construction, satellite servicing, and the Orbit Transfer Vehicle as separate activities. These contracts, however, seek additional answers for these activities in relation to the space station itself. "What we are asking for in these new studies," said Marshall, "is to define the role of an early space station in the development of these space construction, satellite servicing and transfer vehicle activities. The contracts will have these aerospace firms to examine what experiments we need to carry out with an early space station in order to learn how to build and use most effectively a fully operational station by the end of the 1990's."

GETTING AWAY

The successful launch of a Space Shuttle depends on thousands of actions being completed in the few seconds before the reusable spacecraft leaves the pad. One of the most important is for the craft to be released from its fixed position; each of the Solid Rocket Boosters is firmly attached to four posts with 150 lb (68 kg) bolts. An explosive nut at the top of the bolt and a nut at the bottom are tightened to preload the bolt to a tension of up to 850,000 lb (395,000 kg). At launch time, the Shuttle's main engines are ignited, and ignition signals are sent to the Solid Rocket Boosters when full thrust is developed. Simultaneously, the explosive nuts at the tops of the bolts are triggered. The pre-tensioned bolts are expelled downward into deceleration stands and the fractured halves of the explosive nuts are contained within debris catchers. One of the less spectacular aspects of space flight, no doubt, but a vital one nonetheless.

BALLOON ATMOSPHERE PROBE

A giant yo-yo device designed to conduct future studies in the atmosphere from balloons proved to be highly successful during its first test flight in September. The flight showed that an instrument package can be lowered 16 km below the balloon and hoisted up again, as a yo-yo is, using energy generated and stored during descent. During the test, the required energy for the reel-back came from 54 kg of storage batteries. The balloon and its package rose to an altitude of 41 km; the package was reeled down to 12 km and then back up. The downward journey took approximately 27 minutes, the return a further 36.

Scientists hope to use this system on long duration balloon flights on which the package will be lowered and hoisted back up 10 or 12 times, sampling the stratosphere at different altitudes, times of day and locations.

The primary purpose is to make extensive measurements to help to resolve questions as to whether the stratospheric ozone layer is seriously threatened by synthetic chemicals, such as the fluorocarbons used as refrigerants and, to a diminishing extent, as aerosol can propellants.

NEW SHUTTLE FACILITY

Work has begun at the Kennedy Space Center on what will be a complex of buildings for processing and storage of Solid Rocket Booster segments for Space Shuttle missions.

Under the present system, the live solid motor segments for the boosters are received, processed and inspected in the Vehicle Assembly Building. The aft skirts and aft propellant segments are also assembled there.

NASA spokesmen said that moving these operations to a separate building will reduce hazardous conditions in the VAB.

The move also will avoid affecting the VAB's launch support capability by eliminating conflicts between hazardous work involving the SRBs and non-hazardous operations on the Orbiter, External Tank and assembled booster rockets.

When completed, the new facilities will allow storage of two sets of SRBs, with capability to support more than 20 launches per year.

IN THE PAST

25 Years Ago ...
10 January 1958. A type A Atlas missile is launched from Cape Canaveral in an early test flight. A quarter of a century later, the rocket is still in use.

20 Years Ago ...
9 January 1963. The Relay 1 communications satellite transmitted its first transatlantic TV programmes.

15 Years Ago ...
9 January 1968. NASA awards a contract to Perkin-Elmer for the Apollo Telescope Mount of the Skylab space station.

10 Years Ago ...
9 January 1973. A contract is awarded for the construction of a wind tunnel model of the Space Shuttle Orbiter.

5 Years Ago ...
19 December 1977. Cosmonaut Georgi Grechko leaves the Salyut 6 space station to become only the fourth Soviet to make a space walk, and the first in almost nine years.

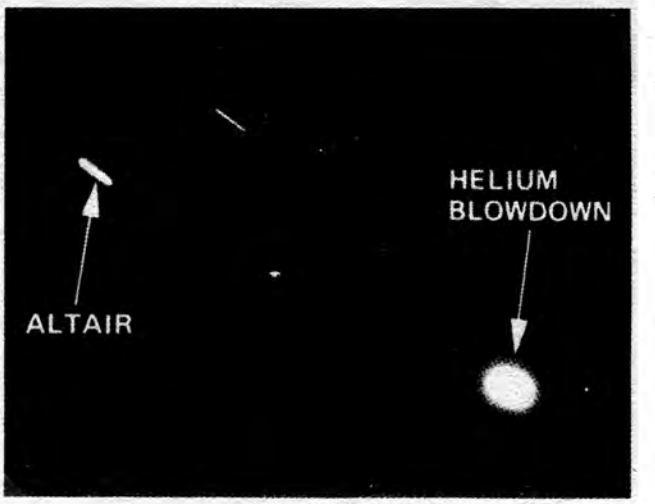
NASA ASTRONAUT BIOGRAPHICAL DATA RECORDS

GROUP 3: October 1963. An illustrated 90+ page booklet containing biographical records of all 14 Group 3 NASA Astronauts, the first of a series, packed with information, selection notes, space experience tables and career assignments. Cost £3.50, plus postage. Postage Rates: UK: 30p; USA, Canada £1.70; Europe 65p: Rest of World £1.25. Obtainable from Dave Shayler, 26 High Farm Road, Hurst Green, Halesowen, West Midlands, B62 9RX, ENGLAND. Send P.O., Cheque or for overseas orders IMO, made payable to ASTRO INFO SERVICE.

ONE EYE AT THE TELESCOPE

By Dr. William I. McLaughlin

Many of us can remember the heady, exciting days when 12 Apollo astronauts walked on the surface of the Moon. But few can claim to have seen the spacecraft crossing the gulf to their targets. Bill McLaughlin, one of our Space '82 speakers, provides us with a personal glimpse at one fascinating aspect of Apollo...



Apollo 12. Helium blowdown from S-IVB initiated at 20.12 GMT on 14 November 1969. Photograph from Bochum Observatory, West Germany at 20.20 GMT. Range: 22,000 km. Courtesy of Heinz Kaminski.

Bellcomm and the Moon

In the Summer of 1968 the last, great push to land on the Moon was underway.

I joined the staff of Bellcomm, Inc. at that time and simultaneously tried to understand the intricacies of the lunar-gravity field *and* survive the wilting heat of a summer in Washington, D.C. Bellcomm was part of the Bell System but an independent company, spun off from Bell Laboratories in 1962 in order to provide technical support to the Apollo programme director [1].

Shortly before the launch of Apollo 9, an Earth-orbital mission, Bellcomm received a request from the Smithsonian Astrophysical Observatory (SAO) to provide telescope-pointing coordinates. My department head, Jim Cappellari, asked if I were interested in the problem, and thus we began almost four years of watching the astronauts cross and recross cislunar space. The purpose of the proposed Apollo 9 photography was to observe the release of oxygen and hydrogen from the S-IVB stage of the Saturn launch vehicle in order to better understand the physics of cryogens in space. NASA foresaw applications of such knowledge to various manned missions, including a future space station.

Jim and I quickly started to work on computing pointing coordinates for the Baker-Nunn cameras [2] of the SAO; we received the request on 18 February 1969, and Apollo 9 was scheduled to lift off on the 28th. We were able to get our results out in time only because the launch was delayed three days, to 3 March. We pumped out all of our calculations over the teletype to the SAO the day before the launch and then (I quote from my notes on launch day): "Tragedy. The S-IVB failed to achieve its planned trajectory."

We obtained a new state vector from the Marshall Space Flight Center, quickly recomputed the pointing coordinates, and this time telephoned the data to the SAO. My journal entry of 4 March is more sanguine: "Triumph! The Smithsonian called. They have pictures of the S-IVB from their Mt. Hopkins, Arizona, and Maui, Hawaii sites." A sticky valve prevented the release of the liquid oxygen, but an SAO photo from Maui showed a more dramatic event: the possible explosion of the cast-off S-IVB rocket [3].

The Astronomer Royal Speaks

After such an explosive start we were committed to optical tracking and began making plans to observe the Apollo 10 circumlunar mission. This time the cryogenic objective was to observe a dump of water from the Command and Service Module (CSM). Such dumps occurred on a regular basis in order to dispose of water generated by the chemical action of the fuel cells.

Apollo 10 lifted off on 18 May 1969 and our rapidly-growing net of observers kept track of the spacecraft, local weather permitting. We were notified that a water dump would occur during the evening of 20 May over Europe, so Jim and I busied ourselves on the 'phone notifying observers at Pic du Midi, Bonn, and the Royal Observatory at Herstmonceux. At Herstmonceux only an attendant and the Astronomer Royal, Sir Richard Wooley, were present. Upon reaching the 'phone and hearing my plea for telescope time in order to observe some kind of celestial water, Sir Richard evidently grew a bit impatient and interrupted me with "Young man, do you realise to whom you are speaking?" I assured him most respectfully that I did, and all went quite well after that. However, we did not achieve observation of any water dump on Apollo 10 due to bad weather and gaps in our observing network.

Apollo 11 was, of course, a thrilling adventure for all of us, but no water dump was observed: the far eastern longitude of the landing site dictated a trajectory that resulted in low spacecraft elevations with respect to the horizon for all observers.

Our observing network continued to grow, eventually consisting of about 300 observers. We included observers at Yerkes, Mt. Wilson and other well-known observatories on four continents and also had many amateur astronomers working with us, including the famed discoverer of 12 comets, Leslie Peltier of Delphos in Ohio [4]. Many of our pointing updates were distributed during flight by Astronet, a group of amateur astronomers/radio operators, located primarily in the western United States and headed by Wallace R. Calkins.

Our persistence was rewarded on Apollo 12 as we finally observed and photographed a water dump [3]. Also the astronauts reported two objects near them on the Earth-Moon leg of their trip. Houston called us for any data we might have and indeed one of our observers had seen two objects in the vicinity of the spacecraft. They were almost certainly two of the four Spacecraft Launch Adapter panels which we frequently observed during Apollo missions [3].

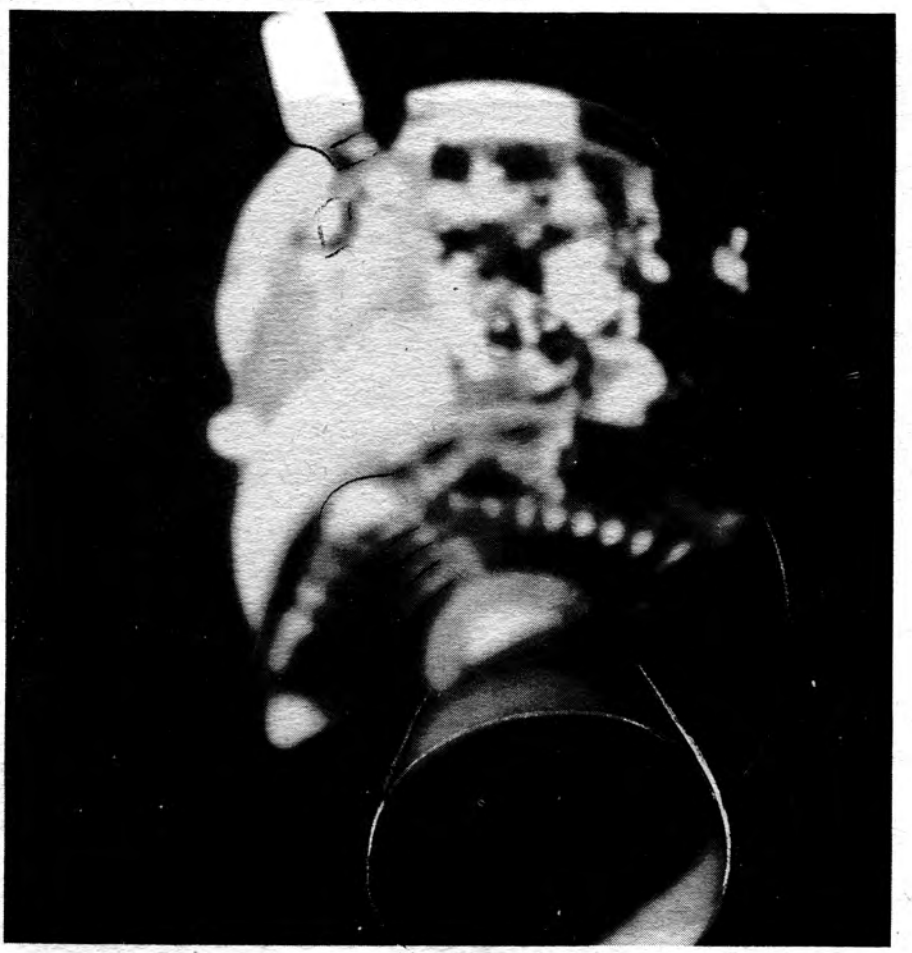
Apollo 13 Explodes

Comet Bennett was a striking object in the early morning skies in the spring of 1970. I observed it with my 3-inch refractor and also attempted to observe Apollo 13 shortly after injection. But after three days of clear weather, clouds moved in 45 minutes before the observing window opened!

I was at home the night of 13 April when the news broke

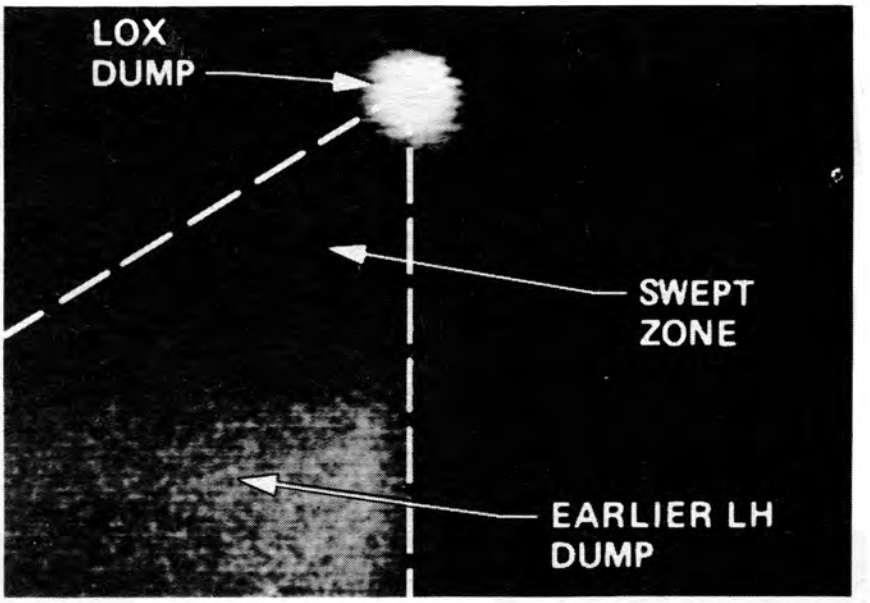
The Saturn 5 third stage provided a tempting target for Earth-based photography durings its translunar journey. This is the S-IVB of Apollo 7, an Earth-orbiting mission.

NASA



The insides of the Apollo 13 Service Module bay containing the oxygen tanks are exposed to space following the explosion of 13 April 1970.

NASA



Apollo 14. Interaction between liquid hydrogen dump of 1000 kg (3.24 GMT on 1 February 1971) and a later dump of 2000 kg of liquid oxygen. Range: 50,000 km. From a video tape made through the 24-inch reflector at Pine Mountain Observatory, University of Oregon. Courtesy of Richard Sears.

that some kind of explosion had crippled Apollo 13 on its way to the Moon. Jim and I immediately started to canvass and notify our observers by telephone. Justus Dunlap of Corralitos Observatory (Las Cruces in New Mexico) had seen the event, as had several other observers.

We continued to track the damaged spacecraft as closely as we could. I quote from my journal entries for this period:

April 14 "We spent the day planning strategy for monitoring the CSM. The situation looks bad. Worked late."
April 15 "Today was a long day of trying to get as many observers as possible watching the spacecraft. Called Pic du Midi in France and the Astronomer Royal in England".
April 16 "Hope grows for the astronauts' safe return with every passing hour ... We've been receiving trajectory updates from both Goddard and Houston."
April 17 "Wally Calkins of Astronet called at 1.30 a.m. Chabot and Pine Mountain have been monitoring the spacecraft and have noticed regular brightenings. These most probably result from thermal-control rotation and lunar module surfaces.

Apollo 13 splashed down in the Pacific with grateful routine."

During the mission all of our relevant observations were reported to Houston to assist in assembling the total picture; the cause of the near disaster was an oxygen tank rupture. See Ref. 3 for a possible photo of the debris.

The Last Apollo

Jim and I worked together on two more Apollo missions. Then, with the programme winding down and Bellcomm about to be reabsorbed into Bell Telephone Laboratories, I moved to the Jet Propulsion Laboratory (JPL) in Pasadena to work on the Mars landings: Project Viking.

I did manage to produce some pointing coordinates for a few observers on Apollos 16 and 17 using the JPL trajectory software. For Apollo 17 I also made arrangements with JPL's Table Mountain Observatory to drive there on the last night that Apollo 17 would be visible and observe it through their 16-inch reflector.

Wally Calkins and I drove the 50 miles to Table Mountain Observatory on 18 December 1972 and, using my pointing coordinates, astronomer Jim Young located the spacecraft for us with the telescope. It was visible as a slowly moving dot of light against the background of stars. We picked it up at 13th magnitude at 11.45 p.m., and it gradually dimmed as it approached the horizon and was seen through more and more air mass.

My final journal record concerning Apollo optical tracking reads: "I finally lost it at 2.44 a.m. (Dec 19) when a tree branch blocked the field of view. I was probably the last person to see an Apollo spacecraft (exclusive of recovery operations)."

Acknowledgments and Bibliography

Thanks are due to the corps of observers, to Dick Sears Michael Gilmore, to Wally Calkins, and to Jim Cappellari.

Further text and photographs from our work can be found in Ref. 5 and in *Sky and Telescope* for July and November 1969, February 1970, and April 1971. Some scientific results are contained in Refs. 6 and 7.

Harold Liemohn may be called "the father of deep-space optical tracking" and one should read his management of Apollo 8 tracking [8] and the magnificent Lunar Orbiter experiment [9].

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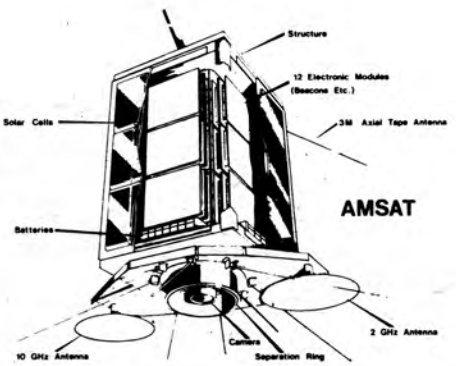
UK SATELLITE REVIVED

UOSAT, a scientific and educational satellite built at the University of Surrey, is operating correctly once more after having been out of action for five months. On 4 April, both the UHF and VHF data beacons were inadvertently switched on together; this had the effect of de-sensitising the command receivers and making them "deaf" to commands from Earth.

In order to regain control, it was necessary to aim the command aerial very accurately and use a much greater signal strength than normal. Attempts were made using progressively larger aerials and more powerful amplifiers, first at Surrey University and subsequently in the USA. Success was finally achieved on 20 September by a team at the Stanford Research Institute in California using a 150 ft (46 m) diameter steerable dish aerial and a high-power UHF amplifier.



The command station at Surrey University then resumed control to check on UOSAT's condition. The satellite appeared to have suffered little from the experience, but the memories of both its computers were checked to ensure that the stored data were still correct.

Since its launch on 6 October 1981, UOSAT has transmitted an enormous amount of scientific information; it has detected a number of electromagnetic "storms" in the ionosphere and has measured auroral activity over the poles. But the features of UOSAT that have aroused particular public interest are its educational experiments: a speech synthesiser capable of broadcasting bulletins in English and a TV camera for taking Earth pictures. Both are intended to be received on the simplest of equipment; a "walkie-talkie" VHF radio is quite adequate. By linking the radio to a simple memory unit, pictures and graphic material can be stored for display on a domestic TV set.

INTELSAT PERFORMANCE

The vast majority of telecommunications carried by the INTELSAT international satellite system is telephone traffic. INTELSAT's 1982 Annual Report, recently released, shows that 85 per cent of the revenue derived by the 106-country cooperative comes from the provision, via its global satellite system, of full-time telephone circuits.

These circuits are used by carriers in countries around the world to provide international telephone calls to the public, as well as other services such as telegraph, telex and data communications. INTELSAT currently handles about two-thirds of the world's overseas telephone calls.

In contrast to telephone, INTELSAT's most visible service, satellite television, contributed only about six per cent to the organisation's 1981–82 revenue. However, it was the most rapidly growing service, with a demand increase during the year of 26 per cent.

In 1981, INTELSAT introduced a new full-time lease service for television to satisfy a growing need for multi-transmission and destination TV networking on an international basis. INTELSAT's other major service segment, accounting for seven per cent of its revenue, was the leasing of satellite transponders to 18 countries for use in their own domestic communications systems.

Total revenue for INTELSAT during 1981 was $249 million and this figure is expected to exceed $300 million for 1982.

INTELSAT reported that the major landmark of the period was the bringing into operation, in the Atlantic Ocean area, of the first INTELSAT V satellite. This event, which occurred during July 1981, effectively doubled the capacity of the Atlantic Ocean primary path satellite. There are now five of the 12,000 circuit capacity satellites in orbit.

The INTELSAT VI satellite is due to come into service in 1986, with a total of nine expected to be launched. Each will carry more than 30,000 'phone calls and several television programmes. As well as additional capacity, the extensive use of satellite switched/time division multiple access (SS/TDMA) techniques will provide the satellites with increased traffic distribution flexibility and enable more efficient use of the available power and bandwidth. The satellites will also have improved capabilities to handle the requirements of regional and domestic leased services. Provision has been made for possible incorporation in later, optional, spacecraft of growth features such as expanded maritime communications facilities, inter-satellite communications links and new frequency band capabilities.

INTELSAT VI will be suitable for launch using either the Space Shuttle or the European Ariane 4 vehicle. The drum-shaped satellite, with a main body diameter of 3.6 m (11.9 ft), will be spin stabilized. When fully deployed in geosynchronous orbit, 36,000 km (22,300 miles) out in space, its length will be 11.6 m (38.1 ft) and its antennae will span 8.3 m (27.1 ft). Its dry weight will be 1,777 kg (3,918 lb).

The satellite will carry six communication antennae including two global coverage horns, two large hemispherical/zone offset-fed reflectors and two smaller spot beam offset-fed reflectors. Power for the on-board equipment is provided through solar cells which cover the satellite's drum-like body. At the end of the satellite's 10-year design life, these cells should still be generating 2.0 kilowatts of power.

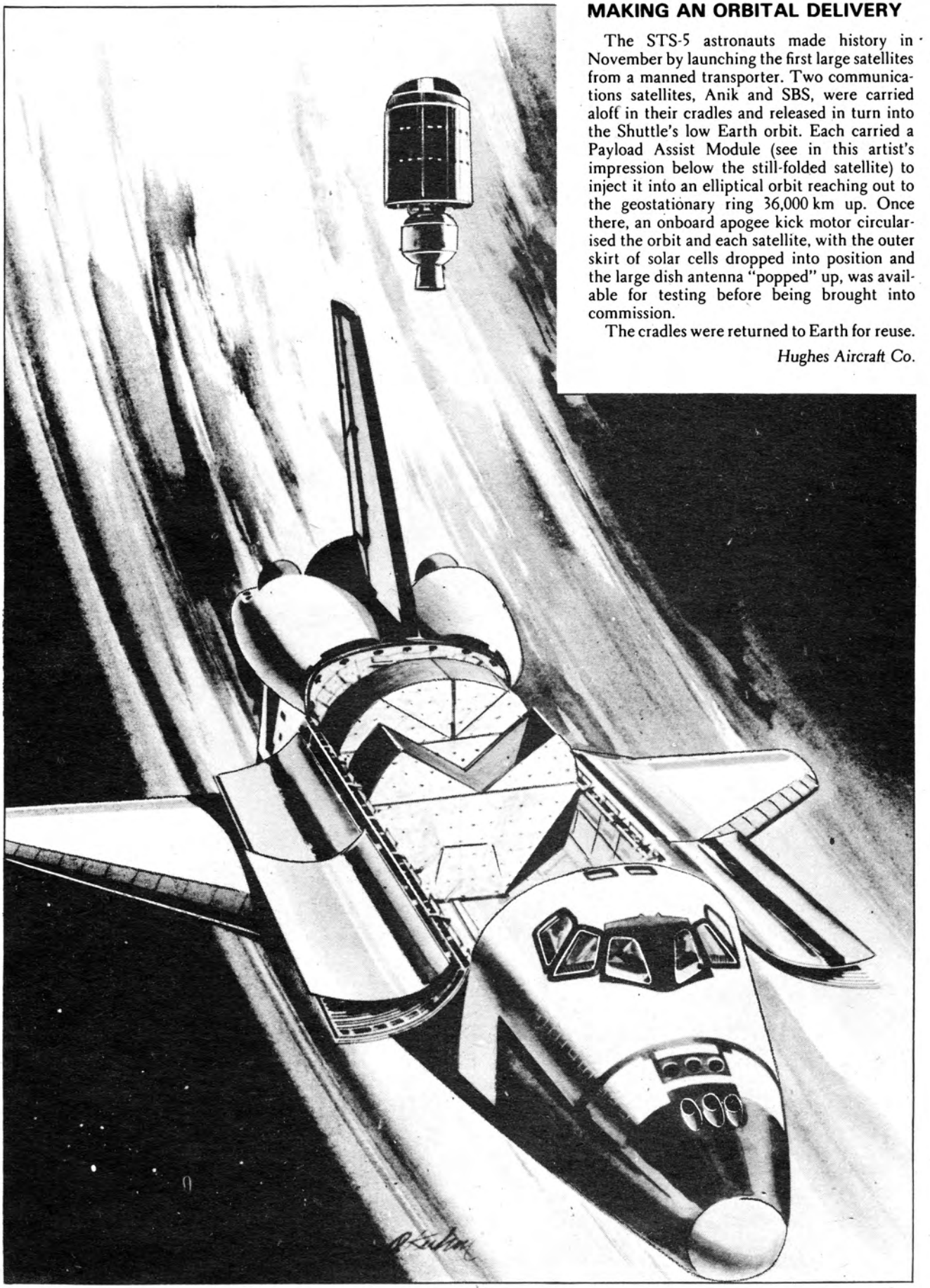
INTELSAT also has on order six V-A satellites. These will have about 25 per cent more capacity than INTELSAT V, achieved by more extensive use of cross polarization techniques through six additional transponders and the incorporation of two, fully-steerable 4 GHz spot beams. They are expected to go into operation in 1984–85.

MAKING AN ORBITAL DELIVERY

The STS-5 astronauts made history in November by launching the first large satellites from a manned transporter. Two communications satellites, Anik and SBS, were carried aloft in their cradles and released in turn into the Shuttle's low Earth orbit. Each carried a Payload Assist Module (see in this artist's impression below the still-folded satellite) to inject it into an elliptical orbit reaching out to the geostationary ring 36,000 km up. Once there, an onboard apogee kick motor circularised the orbit and each satellite, with the outer skirt of solar cells dropped into position and the large dish antenna "popped" up, was available for testing before being brought into commission.

The cradles were returned to Earth for reuse.

Hughes Aircraft Co.



SPACE DEBRIS – A GROWING HAZARD

In the December 1982 issue of *Spaceflight*, Nicholas Johnson reflected on the growing problem of "space junk" in geostationary orbit. Here, Andrew Thomson describes the main points of a "position paper" published by the American Institute of Aeronautics and Astronautics dealing with debris at all altitudes.

Introduction

On 2 July 1982, on the fifth day of its final test flight, the Space Shuttle Orbiter *Columbia* flew uncomfortably close to the burned-out upper stage of a 1975 Soviet Intercosmos rocket. Flying above the north-western coast of Australia (a region still smarting from the dramatic return of Skylab in its midst in 1979!), Ken Mattingly and Henry Hartsfield passed within eight miles of the stage. It flew past them at almost 7,000 mph (11,200 kph) above and in front of the Orbiter. Mission Control said that there was no danger of collision, but that *Columbia* could have taken evasive action if necessary. The Flight Director commented "No way they could have seen that thing. You'd have to be looking at exactly the right place at exactly the right time and not blink".

The incident highlighted the growing hazard posed by man-made space debris. In the 25 years since Sputnik 1 was launched this problem has not been considered to be too serious but, with the possibility of very large space structures in both low and geostationary orbits in the 1990's, it is now a problem that must be faced. In 1981 the American Institute of Aeronautics and Astronautics (AIAA) produced a "position paper" on Space Debris to encourage debate; a similar paper was also read at the International Astronautical Federation Congress that year. The AIAA concluded that "at the present time, the collision hazard is real but not severe." However, "the probability of collision will increase and eventually reach unacceptable levels, perhaps within a decade".

Space Debris

Debris consists of spent spacecraft, spent rocket stages, separation devices, shrouds, clamps, etc, and products of deliberate or accidental explosions. Because of the number of particles they produce, the latter accounts for the majority of space debris. There are three main areas of concern: the tracked population of debris objects, the untracked population, and the future population.

The Tracked Population

At present the North American Aerospace Defence Command (NORAD) in Colorado is tracking more than 5,000 objects in orbit. Most are larger than 10 cm in diameter. Over the last ten years this population has grown at a rate of 10 per cent per year. The greatest concentration of objects is at altitudes between 500 and 1,100 km, the maximum being at 850 km. The probability of collision for the Shuttle Orbiter with one of these objects has been calculated as only 4×10^{-6} for a typical seven day flight.

The Untracked Population

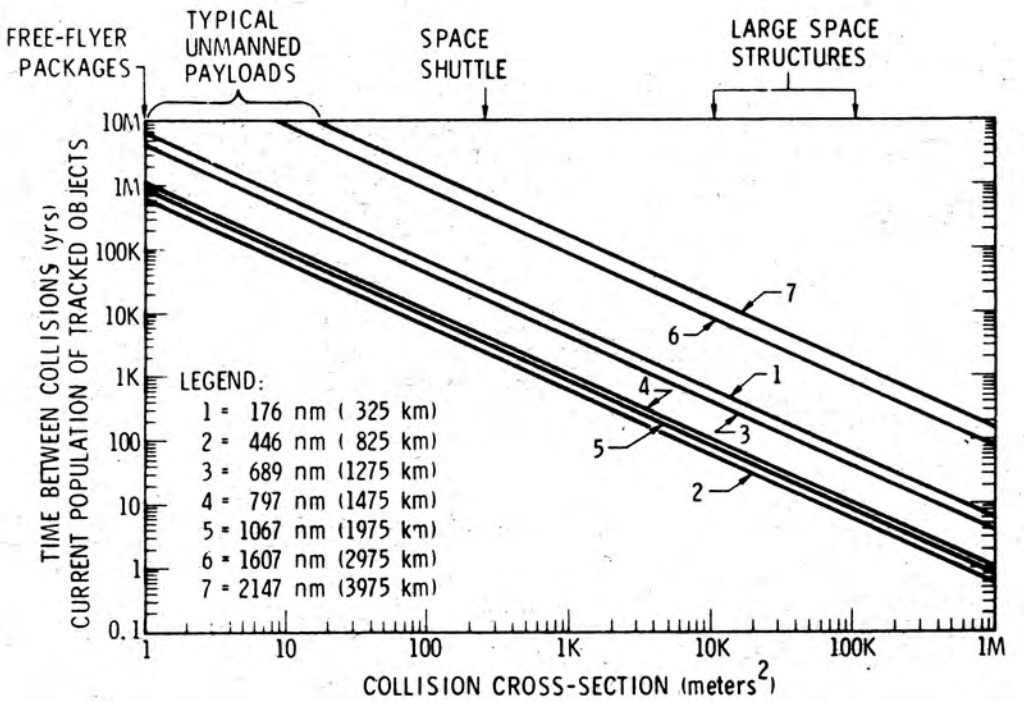
These are mainly the smaller particles which are known to exist, especially those resulting from explosions. Terrestrial tests in which particle distributions from explosions have been studied show that it is reasonable to infer the presence of some 10,000 small particles for every low-intensity explosion and up to 10 million for high-intensity events.

The Future Population

If past trends continue the number of tracked objects in space is predicted to increase by a factor of two to eight (depending on the rate of future explosions) within the next 20 years. In addition there is the possibility of collisions between particles to produce additional fragments.

What Should be Done?

There is at present no strong US or international concern,

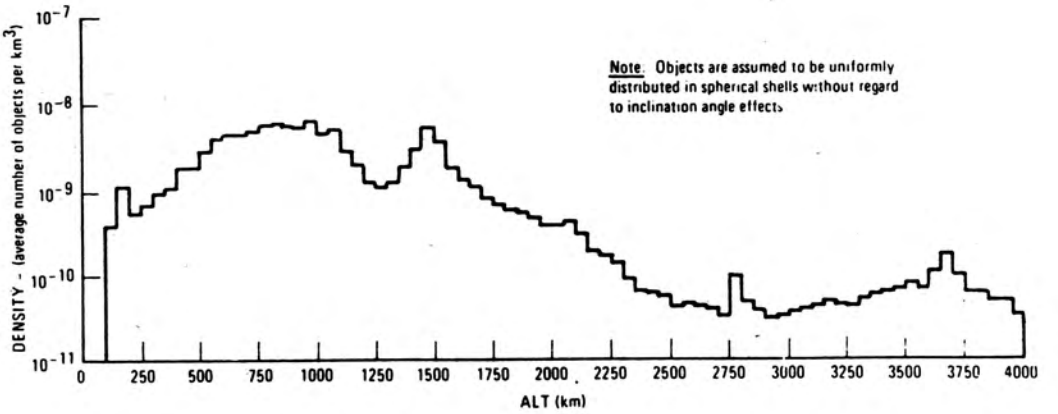


The hazard levels presented by debris currently being tracked. On the horizontal axis is a measurement in sq. m. of the surface area exposed to possible collision (rising from small unmanned payloads on the left to the large space structures proposed for the 1990's on the right, with 10,000 sq. m. and more surface area). The vertical axis shows the expected time in years between collisions; the sloping lines are numbered to indicate the risks at different orbital altitudes.

AIAA

Observed object density vs altitude.

AIAA


Note: Objects are assumed to be uniformly distributed in spherical shells without regard to inclination angle effects
DENSITY - (average number of objects per km³)
10⁻⁷
10⁻⁸
10⁻⁹
10⁻¹⁰
10⁻¹¹
0 250 500 750 1000 1250 1500 1750 2000 2250 2500 2750 3000 3250 3500 3750 4000
ALT (km)

although investigators are studying the problem and bodies such as NASA's Johnson Space Center are attempting to evaluate various methods of minimising the propagation of debris.

Impact protection may not be feasible in most cases because of the likelihood of very high approach velocities (of the order of 10 km per second), and the fact that protruberances such as solar arrays and antennae cannot easily be permanently shielded.

Evasive manoeuvres may reduce the present probability of collision for specific satellites in certain circumstances, but they do not provide a practical long-term solution. In addition there will be the added weight burden on spacecraft of having to carry sophisticated detection equipment (to catch the untracked particles) and propellant to perform the manoeuvres.

Natural drag by the atmosphere is the major factor operating in our favour, but it can take a very long time to be effective, especially from the "busy" higher altitudes, and it causes debris to migrate from higher to lower orbits (thus complicating tracking problems even further).

Collection by "Orbiting Garbage Truck" spacecraft would be extremely difficult and expensive.

The AIAA concluded that the problem can be forestalled by immediate action in five areas:

1 Education on the critical nature of the problem; education of space designers on the need for litter-free systems.

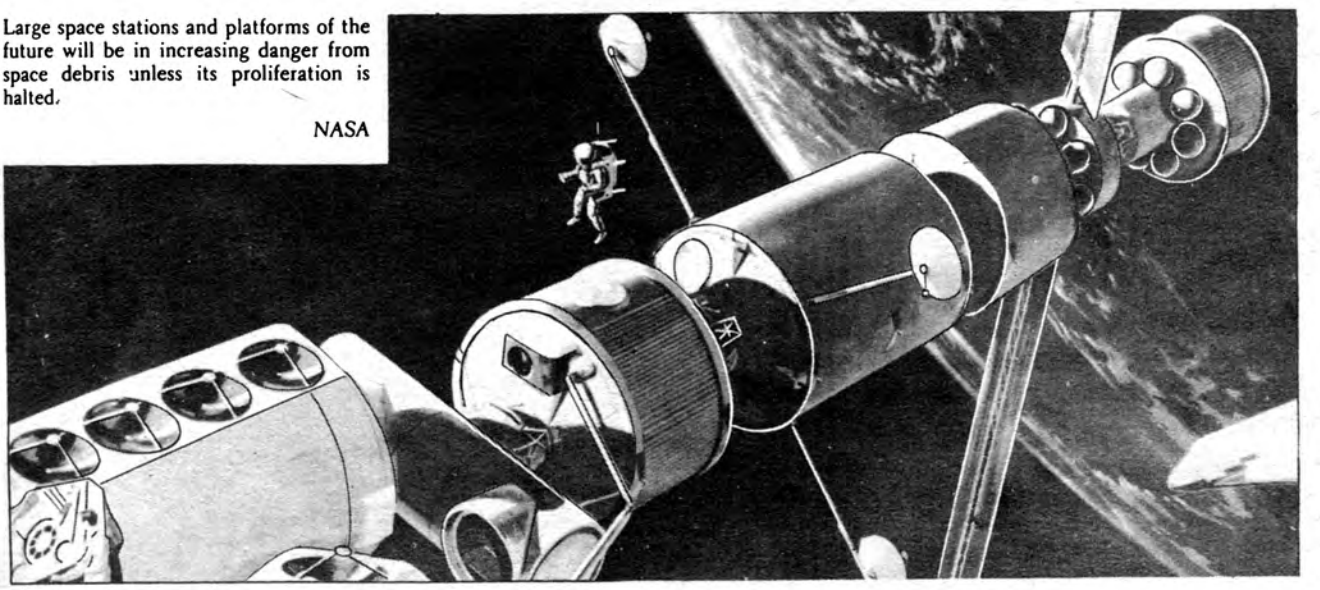
2. Technology: detection techniques, monitoring systems.
3. Space Vehicle Design: especially encouraging disposal by retrieval, re-entry, earth escape, or transfer to selected "dump" orbits.
4. Operational Procedures & Practices: avoiding crowding spacecraft orbits; limiting explosions to low orbits so that particles re-enter quickly; planning launch trajectories to ensure early re-entry of spent rocket stages and dead payloads.
5. International Cooperation: to answer such questions as "Should a policy be adopted that requires all spacecraft to be boosted out of geostationary orbit at the end of its useful life? Should a policy be adopted to regulate which objects may be left in long-life orbits?"

Acknowledgement

With thanks to the AIAA for permission to use their paper "Space Debris: a Position Paper" (AIAA, Technical Committee on Space Systems, July 1981). Copies are obtainable at $2.00 from the AIAA, 1290 Avenue of the Americas, New York, N.Y. 10104, USA.

Large space stations and platforms of the future will be in increasing danger from space debris unless its proliferation is halted.

NASA



ASTRONAUTS FOR THE SHUTTLE

By Curtis Peebles

Introduction

With the transfer of seven ex-military astronauts to NASA in 1969, the first generation of astronaut selection came to a close. In the years that followed, the number of astronauts on active duty dropped from 56 at the start of 1970 to only 27 in January 1978. The lack of flights, age and the lure of new goals exacted their toll.

When the time came again to select astronauts, the process was in many ways a continuation of the old methods. There were differences, though, brought about by increased knowledge of human reaction to space flight, and advances in technology.

Changes

Before the advent of the Shuttle, astronauts had to be "all-purpose". Scientists astronauts had to meet the same medical requirements as pilot astronauts and after selection they had to learn to fly jet aircraft. The Shuttle, because of its complexity, requires a more specialised crew, organised more along the lines of an airliner [1].

The astronauts are now divided into two groups: the pilots and the mission specialists. The pilot astronauts serve as both Shuttle Commanders and as actual pilots. The Commander has overall responsibility for the vehicle, crew, mission success and flight safety. The pilots assist the Commander in controlling and operating the Shuttle and also deploying and retrieving payloads, conducting EVA operations and supporting other payload operations.

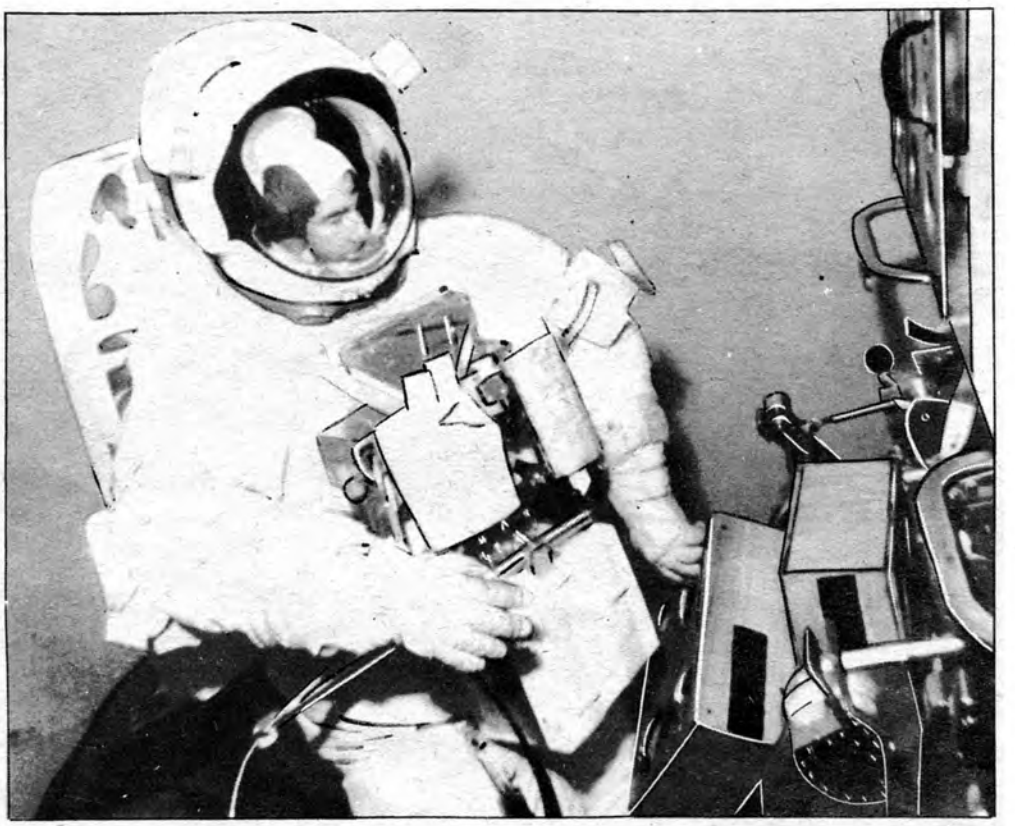
Mission specialists have overall responsibility in the areas of crew activities, planning, consumables (such as electrical power, cooling and fluids), and other activities related to the experiments. They require a thorough understanding of Shuttle systems and mission requirements. They may also take part in EVA, payload handling and repair and operate experiments [2,3].

Selections

In 1978 and 1980, the first Shuttle astronaut selections were made, with the criteria and procedures for the two years nearly identical. Pilot applicants had to have a Bachelor degree from an accredited institution in engineering, physical sciences or mathematics. In the 1980 selection, a biological degree was added. The prospective pilot astronaut also had to have at least 1000 hours pilot-in-command time with 2000 or more hours being desirable. High performance jet aircraft and flight test experience was highly desirable. In the 1980 selection, the flight time *had* to be in jets.

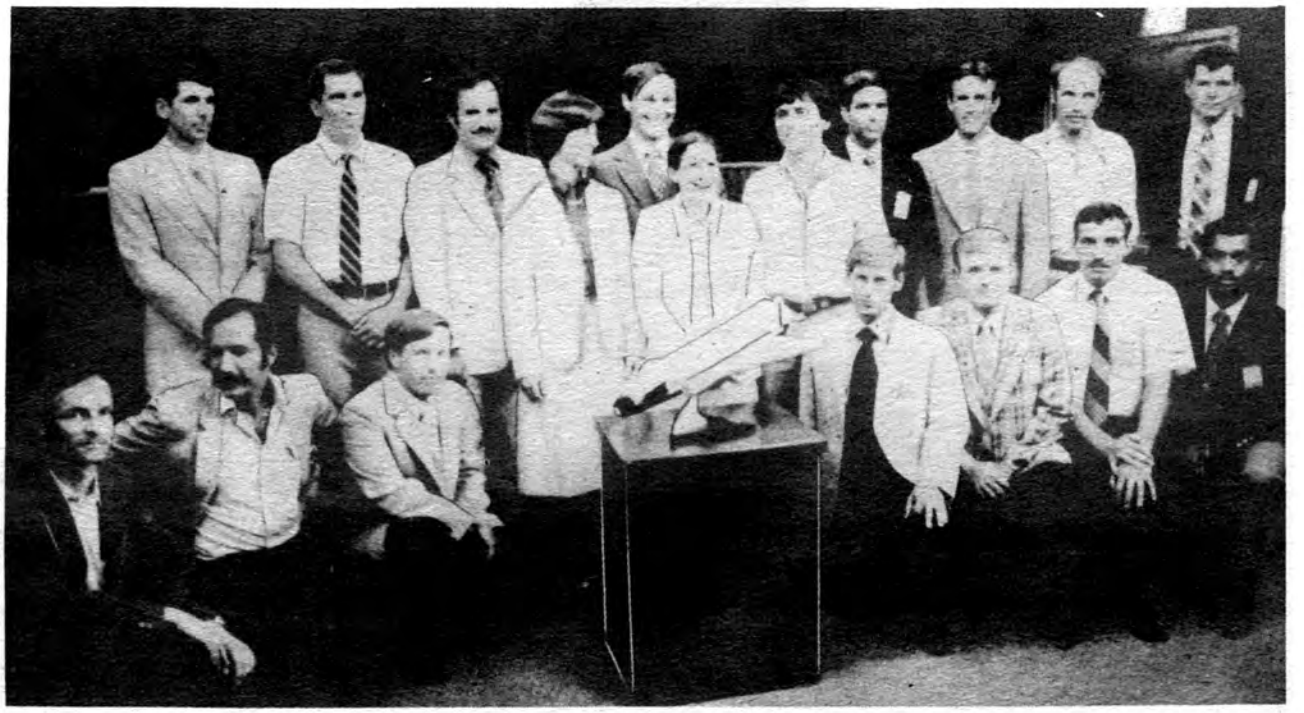
The pilot applicant also had to pass a NASA Class I space-flight physical. This included a distant visual acuity of 20/50, correctable to 20/20, a hearing loss not to exceed 30 db at 500 Hz and 25 db at 1000 and 2000 Hz, a systolic blood pressure not to exceed 140 or a diastolic greater than 90 mm Hg measured in a sitting position. And finally, a height of between 64 and 76 in. (1.63 to 1.93 m). These are the USAF/USN height standards.

The mission specialists had to have a Bachelor degree in engineering, biology, physical sciences or mathematics. In the 1980 selection, the mission specialist also had to have three years relevant experience. An advanced degree could be substituted (Master = 1 year, PhD = 3 years). Another change in the educational requirements was the elimination of degrees in technology, aviation and some in psychology from consideration. The would-be mission specialist also had to pass a NASA Class II physical. The blood pressure requirements



Shuttle Mission Specialists have to undergo EVA training to prepare them for trips from the pressurised cabin. The work could range from repairing damaged thermal tiles to deploying satellites from the cargo bay.

NASA



The second group of Shuttle astronauts. Kneeling, left to right on the front row, are Claude Nicollier and Wubbo Ockels (candidate payload specialists for the Spacelab 1 mission); Richard Richards, Sherwood Spring, Roy Bridges, David Hilmers and Charles Bolden. Standing left to right are Robert Springer, Michael Smith, John Lounge, Bonnie Dunbar, Jerry Ross, Mary Cleave, Franklin Chang, John Blaha, William Fisher, James Bagian and Bryan O'Connor. Not shown from this group are Guy Gardner, Ronald Grabe and David Leestma.

NASA

were identical, the visual acuity dropped to 20/100 but still correctable to 20/20. One ear could have a hearing loss of 35 db at 500 Hz and 30 db at 1000 and 2000 Hz. The other ear had to meet pilot standards. The height requirement was easier: 60 to 70 in. (1.52 to 1.93 m). One requirement was notable for its absence; nowhere in the application was an age limit ever mentioned [4].

These lower standards ensured that the selection process was open to many more people than was previously possible. The strict requirements of previous selections had resulted in otherwise qualified people being eliminated because of such factors as height or age.

Another NASA goal was the selection of women, and people from minority ethnic groups. This had been a source of criticism during the 1960's. In February 1977 NASA hired Women in Motion, Inc. to publicise the forthcoming shuttle astronaut selection. The company's founder, actress Nichelle Nichols, made public appearances and shared films encouraging qualified minorities and women to apply. Her acting experience included three years as Lt. Uhura in *Star Trek* [5]. It should be stressed that there were no quotas; minority candidates were judged on their qualifications only.

Civilian applicants wrote directly to NASA; military personnel applied to their services for initial screening, the best being sent on to NASA. The application forms are almost disappointingly simple. The SF 171 personal qualifications statement is the standard form filled out by anybody applying for a US Government job. It asks such questions as: name, birthdate, is the applicant available for overnight travel, special qualifications and skills, a list of employment, criminal record, education and subject grade, along with many others. Also included in the application package was SF 93, a report of medical history. It listed every medical condition imaginable from tooth fillings to cancer. Pilot astronauts had to fill in CSC Form 671: the supplemental record of aeronautical experience. Finally, JSC Form 490: one page listing what the applicant was applying for, grade point average, graduate examination record, number of combat missions and flight experience as a crew member. The applicants also had to send their college records [6]. For most of the would-be astronauts, the quest for space was over. They got no farther; the great sorting was about to begin.

The Choosing

At Houston, the first step was to find which applicants met the basic requirements. Nearly half did not. All of the military applicants, having been pre-screened, got past this hurdle. The survivors were then screened to find the most highly qualified. For the pilots, the criteria were: demonstrated performance, apparent motivation and potential, response to stressful environment, responsibility, breadth and quality of experience and relevance of education and training. For mission specialists, the selection panel looked for breadth and applicability of education and experience, demonstrated performance, responsibility and potential and unique qualifications or skills.

Once more, the numbers were pared down. The most highly qualified were again reviewed by the panels to find those to go to Houston for interviews. This time, for pilots, NASA looked for the quantity, quality and variety of flying experience. The academic aspect was a key factor for mission specialists. Specifically; advanced degrees, diversity, applicability, quality and how recent. Related experience was also considered, as well as other unique skills or experience.

The references of both pilots and mission specialists were carefully scrutinised [7]. Many of the applicants, it was found, had shaped their education for an astronaut career. They brought with them a depth of education and experience that was not available ten years before. Their backgrounds were

precisely what NASA had found most desirable. For the best, the final step was at hand.

A Week in Houston

The combining of medical tests and interviews was another change from previous selections. The process lasted 40 hours, a normal working week, broken up into medical tests, briefings and interviews. Many of the applicants, having read accounts of the medical tests of their predecessors, braced themselves to face similar horrors. Ironically, the tests the Shuttle astronauts faced were not all that different from an ordinary flight physical - just longer and more thorough. They lasted for some 18 to 20 hours and covered such areas as vision, cardiovascular health, exercise capacity, pulmonary functions and tolerance to acceleration forces. All had to go through a "maximum effort" treadmill.

The standards were designed to ensure the candidates were physically and temperamentally fit for space travel. The tests looked for any defect or disease that would interfere with duties requiring considerable physical exertion and dexterity, visual and auditory acuity and clear speech. Anything that would prevent the use of pressure suits, helmets or similar specialised equipment were also grounds for rejection. The physical detected any sensitivity to rapid changes in atmospheric pressure acceleration or weightlessness. Conditions that required frequent medical treatment or medication or that would be periodically disabling or would become so in time were also reasons for rejection [8].

About 15 hours were spent on briefings. NASA personnel described the Shuttle system and the roles, duties and responsibilities of the astronaut. The applicants also met the older astronauts and saw Houston facilities and personnel. The remaining hours were spent in interviews [9].

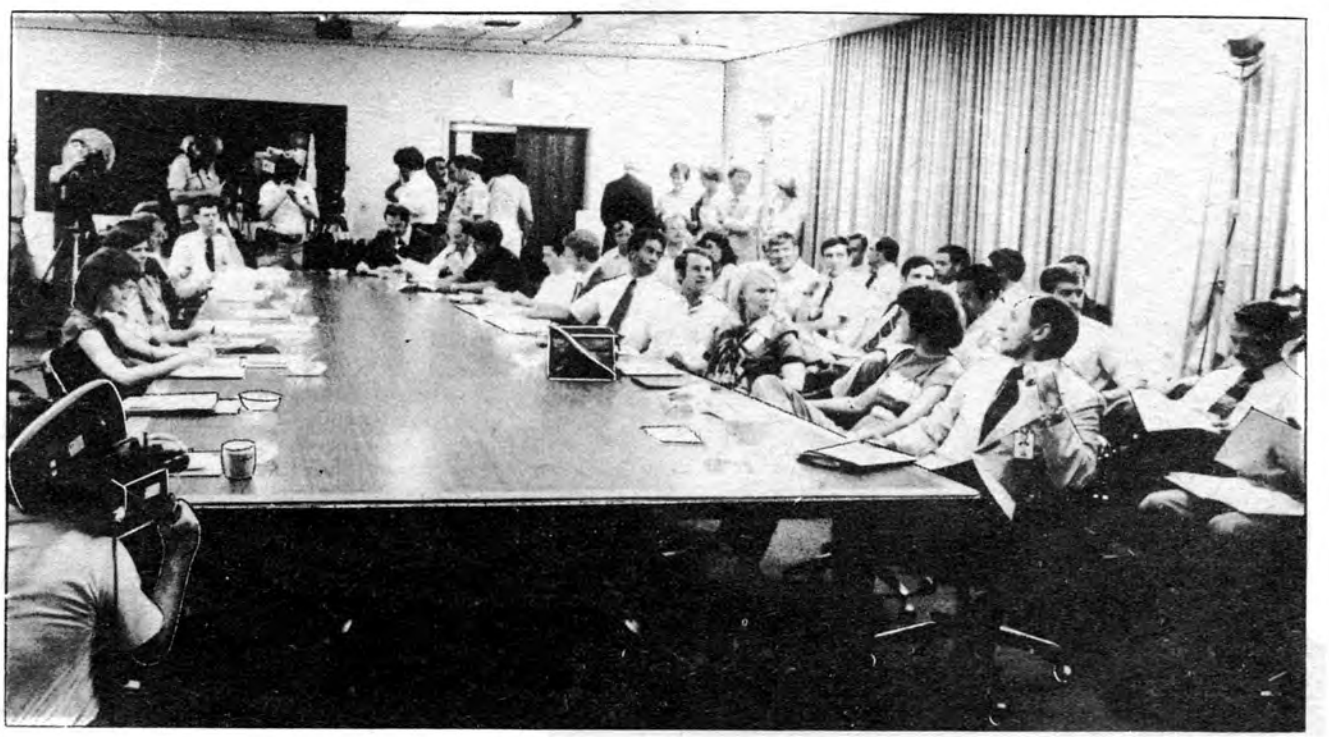
These interviews were conducted by two separate psychiatrists, subsequently dubbed Psy one and Psy two. Both men and women were asked for their reaction to the lack of privacy in mixed Shuttle crews. They were asked: "What should the senior astronaut aboard a disabled spacecraft do if there were only one space suit for six people?" Politics were also probed. In the 1978 selection, the Panama Canal and Northern Ireland were newsworthy. What would a black applicant do about South Africa if he were President? Jews were asked about the Middle East, whites were asked about flying with blacks and everybody was asked about flying with the Russians. To the latter question, one woman responded "I'd fly with little green men if it meant getting into space" [10].

In all, 54 applicants made it through the tests and interviews in 1978 and 1980, moving on to become astronaut candidates to begin their period of evaluation and training. After this period, the candidates were made into full time federal employees. The civilian astronauts are now expected to serve for a minimum of five years, while the military astronauts' tour of duty is governed by a NASA/DOD memorandum of understanding. At the time of the 1980 selection, this was seven years. A tour with NASA would be one part of an officer's career intermixed with school, management and squadron assignments.

The New Astronauts

The backgrounds of the 54 astronauts chosen in the first two selections are very diverse. In terms of degrees, eight of the pilots hold Bachelor degrees and 15 have Masters. Eight have their highest degrees in aeronautical engineering, one in physics and the remaining 14 in other engineering areas. The mission specialists have between them: one Bachelor, 13 Masters and 17 Doctorates. There are five medical doctors, one biochemist, seven aeronautical engineers, four astronomers, three physicists, one geologist and ten in various engineering fields. Many have multi-disciplinary backgrounds that enable them to cover several fields. One doctor has a degree in mechanical engineering, another has the combination of psychology, engineering and medicine [11].

Their individual stories are also informative. Mary Cleave weighs only 98 lb (43 kg) and stands 62 in. (1.6 m) tall. She



Most of the first group of Shuttle astronauts are shown taking part in a meeting to mark their official arrival at the Johnson Space Center on 10 July 1978. At the right end of the table is astronaut Alan Bean.

NASA

Shuttle astronaut David Griggs trains in the Space Shuttle one-g simulator in the mockup and integration laboratory of the Johnson Space Center. Directly in front of him is the Head Up Display (not carried in *Columbia* for the first five missions) that allows him to look through the window and receive flight data at the same time.

NASA

tried to get into aviation as a stepping stone to space but she could not be a stewardess because of her height; she was too short even to sell tickets! Undaunted, she took flying lessons and earned a Bachelor degree in biology, a Master in botany and a Doctorate in civil engineering. At the time of her selection in 1980, she was working in a water research laboratory [12, 13]. At the other extreme is Steve Nagel, who at 74 in. (1.8 m) would have been too tall for the Apollo programme. Fred Gregory, a black Air Force pilot, overcame a seemingly unsurmountable setback. His piloting experience was mainly in helicopters, both flying rescue missions in Vietnam and as a helicopter test pilot. He had limited experience in jets. The Air Force reviewed all of its personnels' applications and, in its view, his experience in helicopters was not suitable for nomination to NASA. Gregory submitted a civilian application and offered to resign from the Air Force if that was required. He was selected in 1978. Husband and wife William and Anna Fisher both applied for the 1978 selection but Anna was picked and William was not even called for an interview. Subsequently, he learned to fly, received a Master in biomedical engineering and was picked in the 1980 group [14].

Future Selections

At the time of the 1980 selection, NASA announced an annual selection programme. The process was to be conducted on a regular basis to prevent long periods between selections. The number picked and the interval would depend on Shuttle needs and the loss of established astronauts. It is expected that the older astronauts will start to retire once they make their long-awaited flights. Replacements will also be needed for military personnel when their tour of duty with NASA is completed. Gaps will be filled as soon as they occur [15].

Virtually all of the Shuttle astronauts had wanted to be astronauts for years but they were hampered by the infrequent selections. With regular selections, students can plan their academic and professional work with the assurance that they will have at least the chance to apply [16].

The background of Shuttle pilots may undergo a major change if a unique experiment is successful. The American Society of Aerospace Pilots has been formed to promote the future of commercial Space Shuttle flights. It was set up by United Airlines representatives in the Airline Pilots Association Master Executive Council. Membership is limited to pilots holding a seniority number on an airline seniority list; they can be active, retired or furloughed. ASAP will offer a two year home study course being designed by the United Airlines Flight Training Program Development Department. It will use text books, video tapes, computer terminals, lectures, films and similar procedures based on NASA astronaut training. Ultimately, ASAP hopes to have a simulator for providing Shuttle experience [17].

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THE END OF AN ERA: 10 YEARS ON

THE LAST APOLLO

Ten years ago, on 19 December 1972, the Command Module of Apollo 17 splashed down in the Pacific Ocean to bring the first period of manned exploration of the Moon to a close. Twelve men had wandered across the surface of our nearest celestial neighbour, at a cost of $2,500 million, and brought back almost 400 kg of samples.

Celestial mechanics dictated that the last man-carrying Saturn 5 should leave Cape Canaveral during darkness to reach its Taurus-Littrow target. Apart from that, the countdown seemed like any other until suddenly, at T-30s, the computers controlling the automatic sequence called a hold and stopped the clock. Nothing like it had ever happened before and there was a chance that the launch escape system would fire to pull CM *America* and its three occupants away from a dangerous, explosive rocket. However, everything stayed in place as ground controllers realised that the S-IVB tank pressurisation with helium had not occurred, and the sequencer had sensed the failure and stopped the countdown. In fact, they had tried to complete the pressurisation under manual control but did not do it fast enough to satisfy the watching machines.

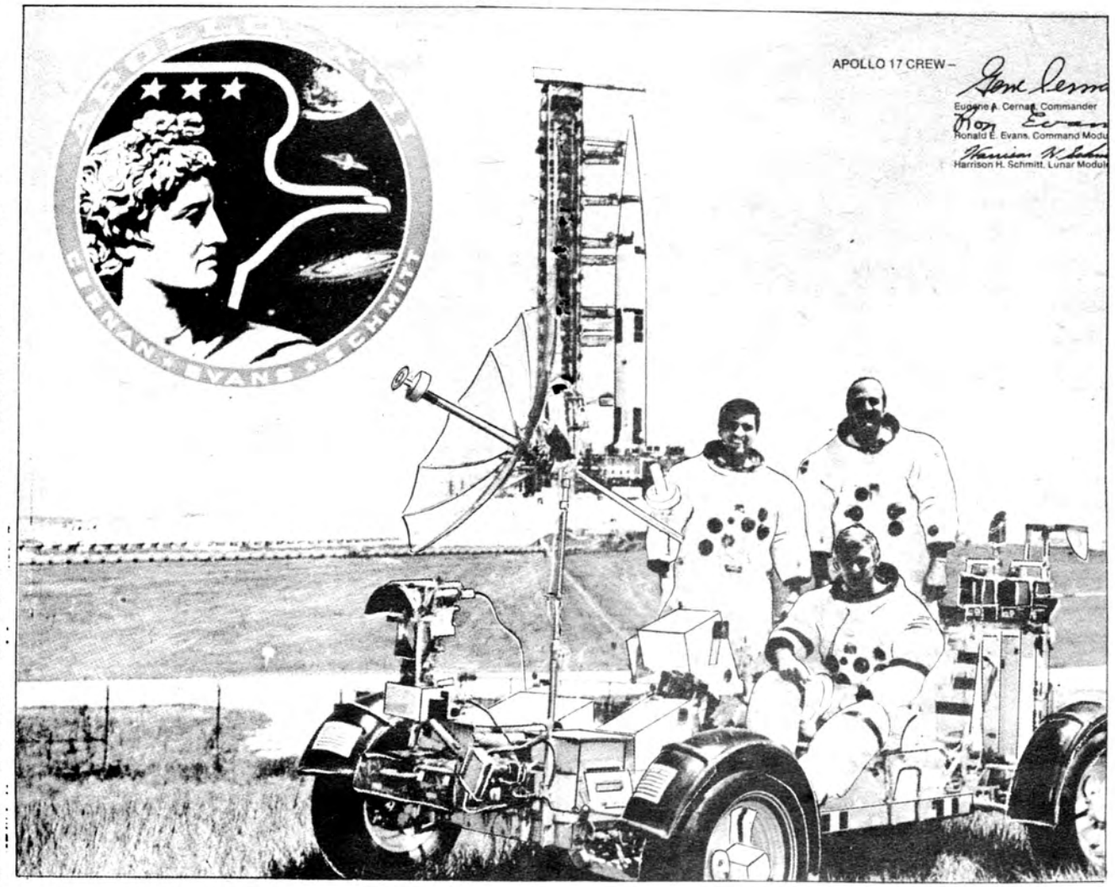
The count was recycled to T-22 minutes and this time everything went normally. AS-512, weight 6,446,000 lb (2,923,000 kg) and producing a thrust of 7.665 Mlbf (34.094 kN), lifted off into the night sky shortly after local midnight on 7 December, bathing the ground for miles around in artificial daylight.

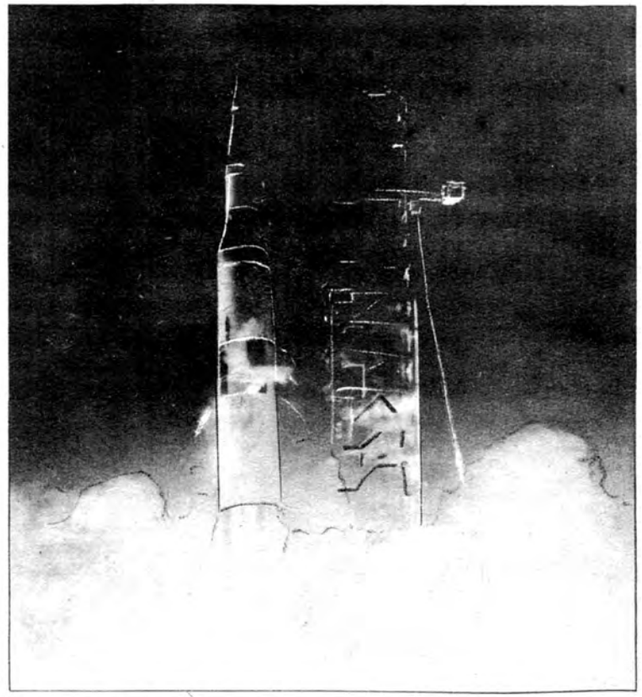
By slightly altering the flight plan, they were able to make up the two hours 40 minutes delay and *Challenger* slid down to its landing site between the North and South Massif mountains on 11 December. EVA 1 began four hours later with the major task of setting up the ALSEP package. Apollos 12-16 had carried the same sort of ALSEP but Apollo 17 had some different experiments, notably a gravimeter to look for gravitational waves and detectors to pick up dust hitting the Moon from space or being thrown up as secondary material from larger impacts. Another heatflow probe was carried because John Young had broken the one taken on the Apollo 16 mission. The seven hour 12 minute EVA included a drive to Steno Crater for sampling.

EVA 2, at seven hours 37 minutes, ended up as the longest Moonwalk to date but it is best remembered for its discovery of orange soil at Shorty Crater. Al Worden in Apollo 15 had spotted cinder cones of volcanic origin in the Taurus-Littrow region – his observations had been a major factor in landing there – and it was hoped that Shorty was volcanic in origin. Speculation about the orange soil even included a comet hitting the surface but analysis back on Earth showed that the colour came from chemically-coloured glass beads, probably volcanic.

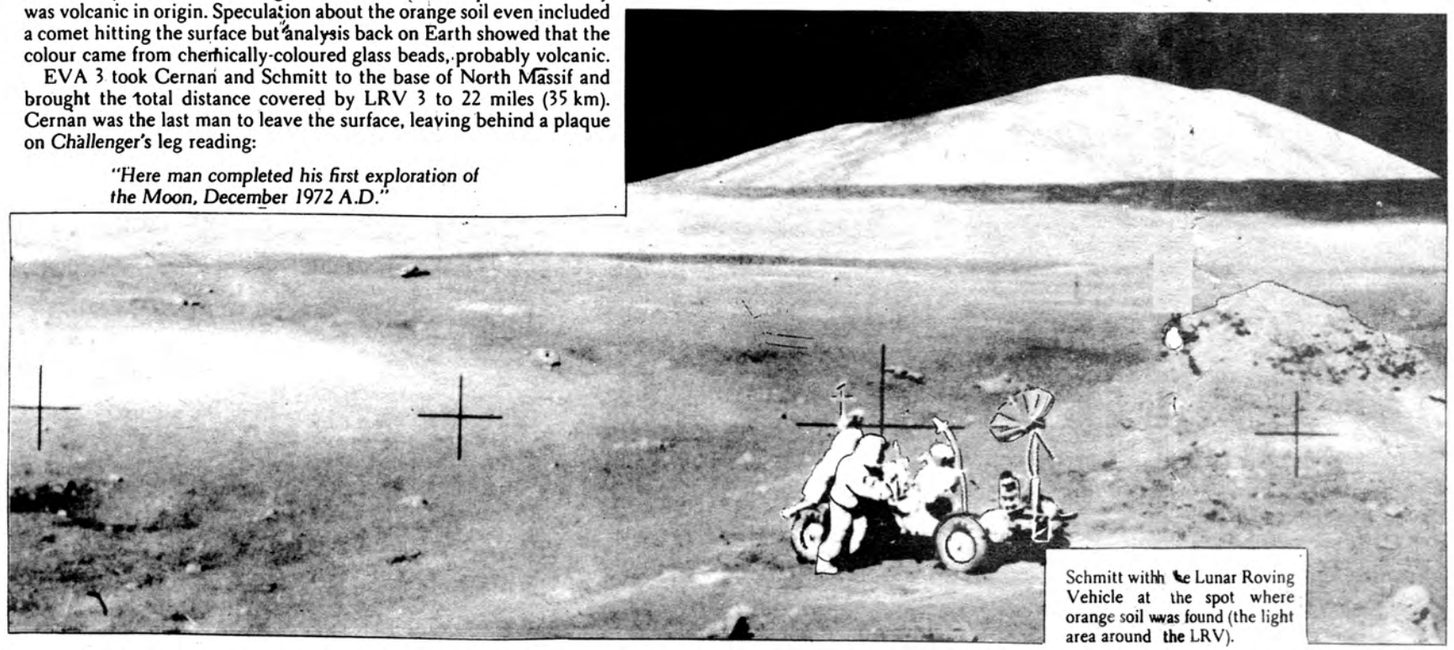
EVA 3 took Cernan and Schmitt to the base of North Massif and brought the total distance covered by LRV 3 to 22 miles (35 km). Cernan was the last man to leave the surface, leaving behind a plaque on *Challenger*'s leg reading:

"Here man completed his first exploration of the Moon, December 1972 A.D."

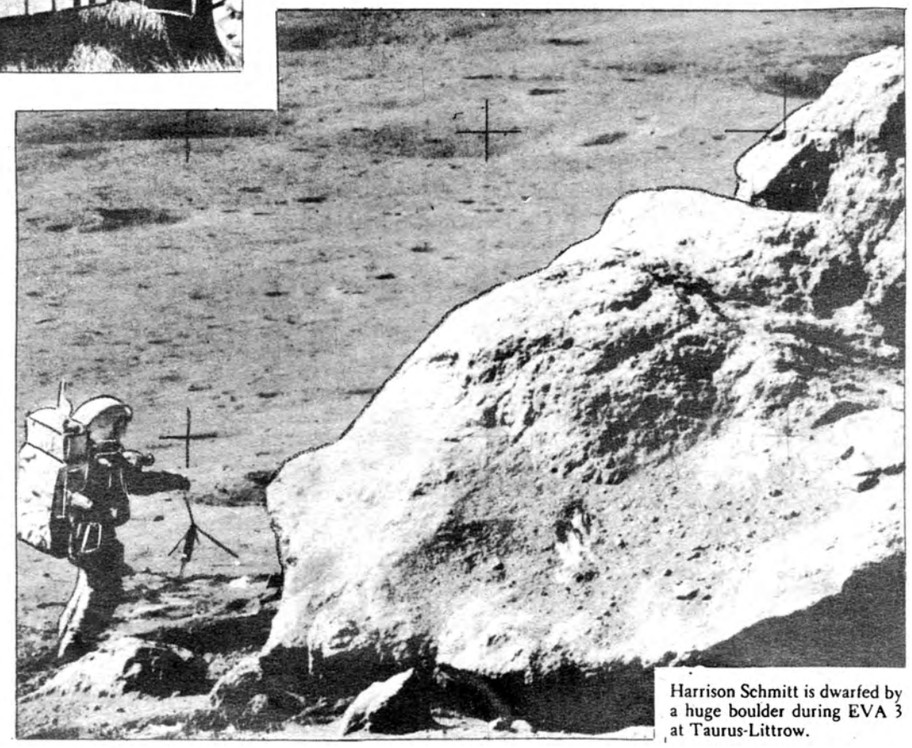




– The last launch of a full Saturn 5 (the Skylab vehicle had only the first two stages live), at 00.33 local time on 7 December 1972. The night firing bathed the Cape area in light as if from an artificial Sun.



Schmitt with the Lunar Roving Vehicle at the spot where orange soil was found (the light area around the LRV).



Harrison Schmitt is dwarfed by a huge boulder during EVA 3 at Taurus-Littrow.

ORBITING QUARANTINE FACILITY: THE ANTAEUS REPORT

By Petter Hesselberg

Introduction

The automated experiments of the Viking landers detected no conclusive evidence of life in the Martian soil. Still, due to the inherent limitations of present-day automatic analysis, and the fact that only a very small fraction of the planet's surface was examined, it is not certain that Mars is barren.

A much more detailed and definitive analysis of Mars' soil could be carried out if a sample were brought to Earth. It would then be highly desirable to guard the terrestrial biosphere against contamination by potentially hazardous microorganisms.

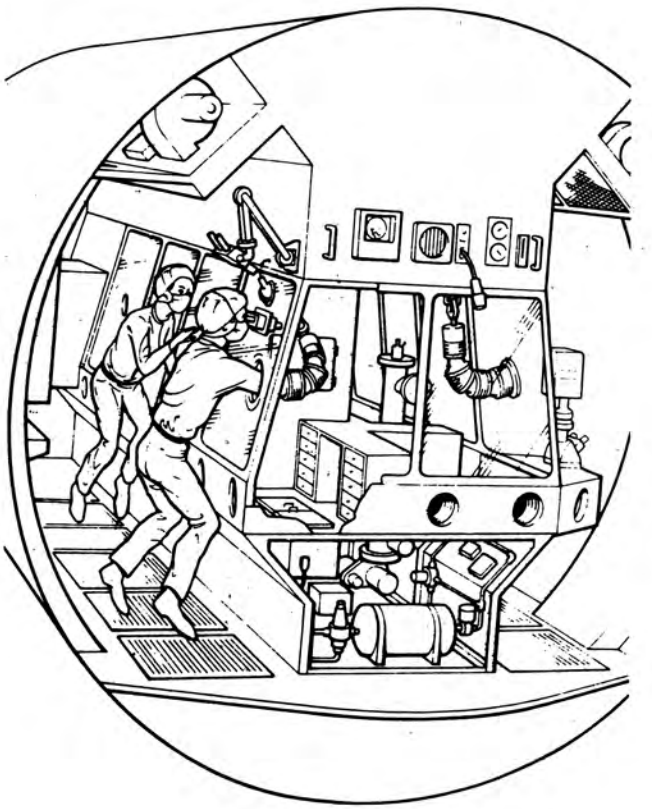
There are three basic ways of doing this. First, one might sterilise the samples *en route* from Mars. Second, one might contain them in a secure terrestrial laboratory (see, for example, Michael Chricton's novel *The Andromeda Strain*). Third, the samples might be contained and tested in an Orbiting Quarantine Facility. This last alternative is discussed by the Antaeus Report from NASA (SP-454).

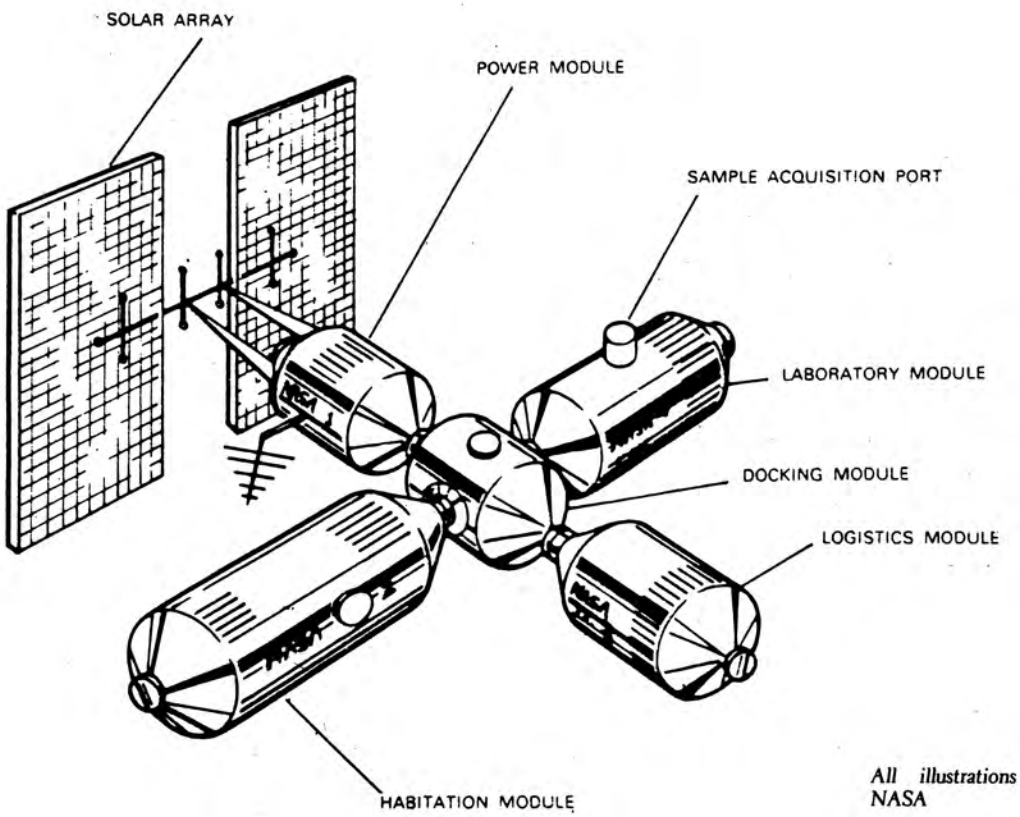
Antaeus was a giant of Greek mythology who drew his strength from the ground, and thus was invincible as long as he had contact with the Earth. He was finally defeated by Achilles, who strangled him while holding him up in the air.

The major advantage of orbital containment is its great degree of security. Depending upon the results of the analysis, one could choose what to do with the samples:

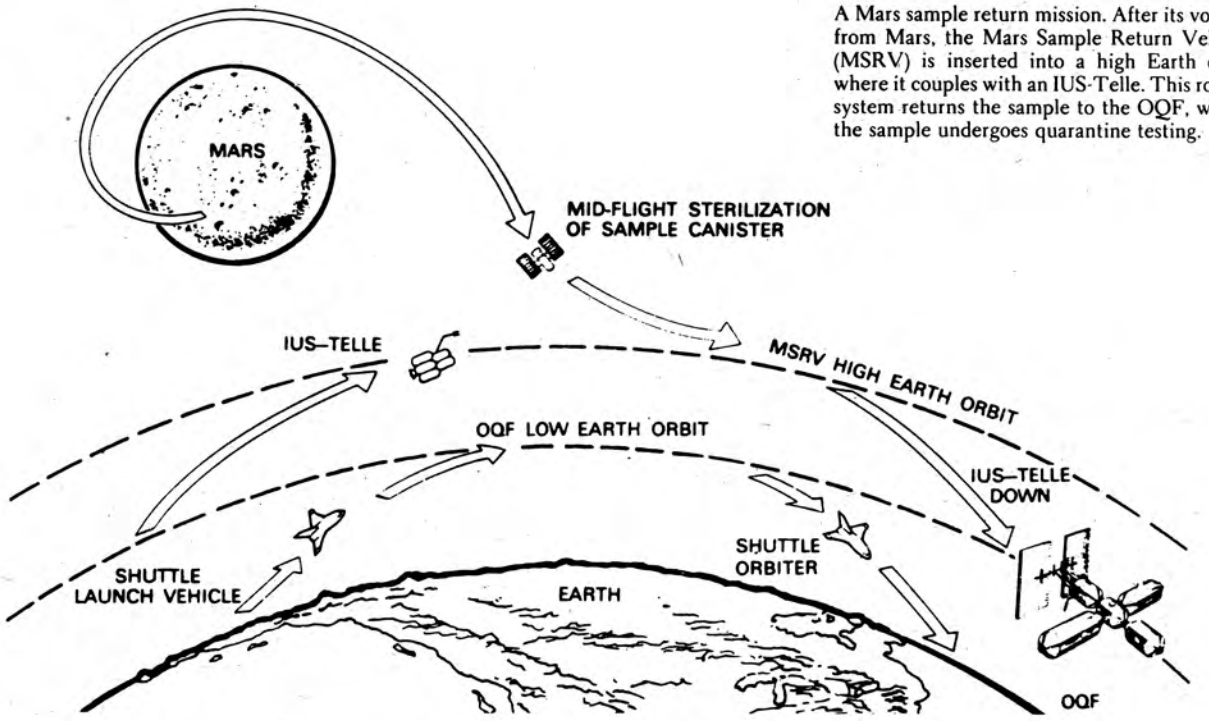
1. unqualified release to Earth,
2. sterilisation prior to release,
3. indefinite retention in space for prolonged study,
4. boosting the sample-containing facility into a distant orbit.

No other method offers such a large range of options.





All illustrations courtesy of NASA



A Mars sample return mission. After its voyage from Mars, the Mars Sample Return Vehicle (MSRV) is inserted into a high Earth orbit where it couples with an IUS-Telle. This rocket system returns the sample to the OQF, where the sample undergoes quarantine testing.

The Design

For cost-effectiveness, it was felt that the OQF should be built using existing or near-future technology. Before it decayed, Skylab was at one time considered as a part of the facility. It was rejected because it was incompatible with the Space Shuttle. It was decided to use modified Spacelab Modules, to be carried aloft by the Shuttle.

In the final configuration, the OQF consists of five modified Spacelab Modules, four of them connected spoke-fashion to the fifth.

The most important section is the *Laboratory Module*, where all the testing would be carried out. The module has a central containment cabinet, accessible by manipulative arms. Portions of the cabinet can be maintained under simulated Martian conditions; other controlled environments can also be produced.

As in Earthly-hazard containment facilities, the Laboratory Module itself acts as a containment barrier. All equipment leaving the laboratory is sterilised and packed in leakproof containers. Personnel entering or leaving the laboratory must pass through a decontamination area. The module also has independent life support and waste management systems, and it is held at a pressure slightly lower than the other modules to prevent leakage outwards.

The laboratory is fully equipped to perform the tests demanded by protocol. It also provides all other necessary laboratory equipment, including a scanning electron microscope.

The *Habitation Module* is the crew's living quarters. It has small, private cabin spaces, plus exercise and personal hygiene facilities. The module also houses the environmental control and life support systems that provides for the whole OQF, except the Laboratory Module. Central control of the OQF is also located here.

The *Power Module* provides the system with up to 35 kW of power from two solar cell panels. The power module is also responsible for thermal control of the OQF, as well as maintaining a stable orbit.

Then we have the *Logistics Module*, which provides storage for supplies and waste materials. Its storage space is sufficient to support a 30-day mission.

Last is the *Docking Module*, which connects the other four. It has an airlock for access to space, as well as docking facilities for the Shuttle. If necessary, two more Spacelab Modules may be connected to it.

The crew would probably consist of five persons: a commander (an astronaut/engineer) and four scientists. These would most likely be a medical doctor, a geobiologist, a biochemist and a general biologist. Their tasks would be operation and maintenance of the OQF, as well as laboratory work.

The Antaeus Report assumes that a relatively small quantity of extraterrestrial soil would be available for testing (about 100 g). The untested portion would remain unaltered, awaiting the test results.

The testing consists of five distinct phases. First, there is chemical analysis; for example, amino acid analysis. Next, there is a microscopic examination, including examination with the scanning electron microscope and examination under ultraviolet light. Third, there is metabolic testing, including the tests that were performed by Viking 1 and 2. Fourth, there is microbiological culturing, that is, the attempted growth of potential organisms on various media. Last we have the so-called culture challenge phase. Here, Martian soil is introduced into cell cultures representing a cross section of terrestrial biology.

If the results of all this testing show no evidence of extraterrestrial life forms, the remaining soil would be sent to Earth for further testing. However, if biological activity were detected, a second series of tests would be performed to determine the characteristics of the organisms.

The OQF would be very useful even beyond its primary purpose. The Laboratory Module would be valuable in any life-sciences programmes; the other modules are essentially independent of the mission type and could be docked with modules dedicated to any purpose. Currently planned Spacelab missions last up to seven days; these could be significantly extended by using the OQF. It could also be very useful for any kind of hazardous research. An example of this is recombinant DNA research, which demands very tight security.

SALYUT MISSION REPORT

PART 12*

By Neville Kidger

Manoeuvres in the Cosmos

As recounted in the last part of the Mission Report (*Spaceflight*, April 1982), the Soviet Union launched Kosmos 1267 on 25 April 1981 into a close-Earth orbit with its plane some 10 degrees East of that of the then-occupied Salyut 6 space station. The Kosmos space station module was then manoeuvred to a docking with Salyut 6, by that time unoccupied, on 19 June 1981.

On 24 May the Kosmos ejected a reentry vehicle which was, by all accounts, recovered in the USSR. The Soviets appear to have indicated two weights for the station module: about 15 tonnes and "over 10 tonnes". The difference is thought to account for the reentry vehicle. The total mass when docked with Salyut 6 has been quoted as about 32 tonnes (the main station's weight is about 19 tonnes). The Soviets never acknowledged the fact that a vehicle was ejected and recovered from the Kosmos module.

The combination was maintained close to the operational orbit of Salyut 6 (around 350 km) by using the Kosmos propulsion system. It was de-orbited on 29 July 1982.

The book *Sovietskaya Kosmanavitika* (Moscow, 1981) and the magazine *Aviatsiya i Kosmanavtika* (April 1982) have both carried pictures of cosmonauts in the underwater training facility at Zvyodznyy Gorodok, training with a truncated Salyut, i.e. minus the forward transfer section of the Salyut with a hint of a circular vehicle forward of the Salyut, but separate from it. These pictures may show the Kosmos module, or a variant of it.

Testing the Systems

The Soviets noted that the Kosmos module contained guidance, life-support, thermal regulation, power supply and other major systems which were intended for long duration tests. Noting that the module was the precursor of future specialised space station modules for carrying varied scientific equipment, the Soviets said that the modules would be capable of being docked to Salyut stations or positioned close by in orbit to avoid disturbances during experiments such as materials processing.

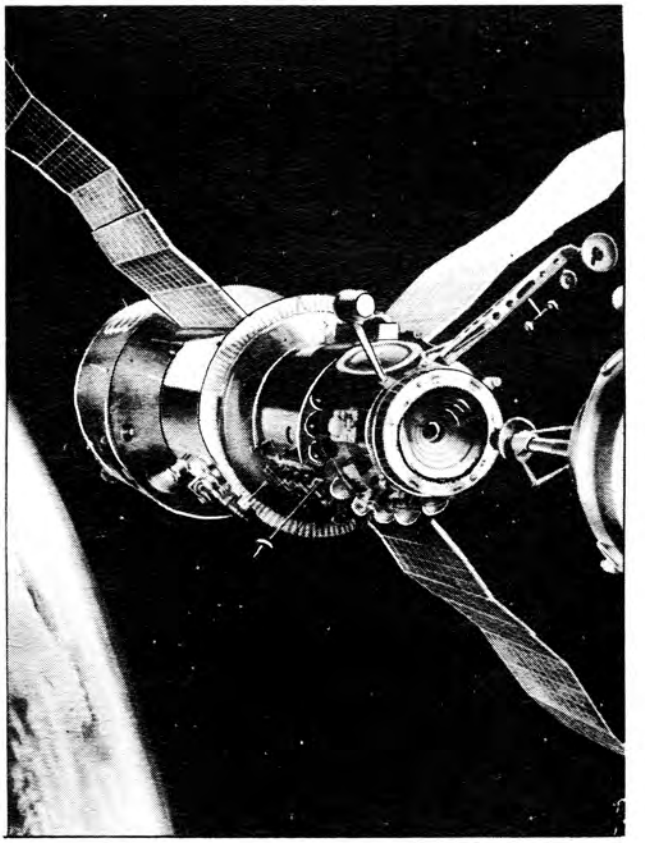
The US magazine *Aviation Week and Space Technology* reported in its 30 November 1981 issue that the Kosmos module also had a more sinister mission. The magazine, apparently quoting reliable US intelligence sources, claimed it was carrying firing pods equipped with 1 m-long miniature vehicles guided by infrared sensors for use as an antisatellite weapon. The Soviets said nothing publicly about the report.

A New Beginning

In preparation for the resumption of manned flights, to Salyut 7, the Soviets expended considerable effort on renovating and expanding the facilities of the Kaliningrad Flight Control Centre (FCC) while spare equipment was used to control the flight of the Salyut 6/Kosmos 1267 combination. The work included the addition of a third control room for controlling the flight of two spaceships (Soyuz and Kosmos modules?) as well as the orbital station. This meant that the Soviets had three control rooms available for Salyut 7 missions.

Soviet spokesmen noted that the new orbital station would have a design life of four to five years, in contrast to the Salyut 6 design life of 18 months.

Early in 1982 Soviet cosmonaut chief Vladimir Shatalov noted that, of the Soviet's about 50 active cosmonauts, 16 were training for missions. Shatalov noted that training for missions was no longer dominated by physical and psychological considerations but rather the development of practical skills for Earth observations – geology, oceanography and meteorology. Cosmonauts now needed to be trained observers.



Soyuz undocking from Salyut (1975 drawing by A. Ryzhov).

Novosti

New Salyut in Orbit

Salyut 7 was launched atop a Proton rocket from the Baikonur Cosmodrome on 19 April 1982 (11 years to the day after the launch of the first Salyut station) into an initial 219×278 km orbit with a period of 89.2 minutes. Despite speculation that, since cosmonaut crews had been observed training in arctic conditions in the Soviet far north, the new Salyut might fly at an inclination of 65 degrees, Salyut 7 occupied the same 51.6 degree inclination as its predecessor (although it was separated by some 70 degrees in orbital plane from Salyut 6).

Control was handled from the FCC, Soviet ground stations and the tracking ship *Akademik Sergei Korolev* stationed in the Atlantic Ocean. In late April the station was manoeuvred using its own Joint Propulsion Unit (ODU) into a 308×352 km orbit, and then to its operational orbit.

On the ground, two 40 year-old cosmonauts were preparing for the Soyuz T-5 mission. Commander was Anatoli Berezovoi who was selected to become a cosmonaut in the 1970 pilot group. Although it was his first flight he was reported as being

* *Since, during the period covered in this report, there were two Salyut space stations orbiting the Earth, the title of the series has been changed from "Salyut 6 Mission Report" to that given above.*

a reserve on at least one occasion for earlier missions. Berezovoi's partner was preparing once again for a second trip into space. In March 1980, Valentin Lebedev had been training for a flight to Salyut 6 with Leonid Popov when he damaged knee ligaments in a trampoline accident. Three days younger than his commander and a cosmonaut since 1972, Lebedev had made his first flight in Soyuz 13 with Klimuk.

Soyuz T-5 in Space

Berezovoi and Lebedev were launched at 0958 (all times GMT) on 13 May 1982. Within nine minutes the spaceship was in orbit. Although it had been almost nine years since his previous flight Lebedev noted that he felt as though he had returned to weightlessness after only a day. (For the first two days both men noted the customary rush of blood to the head but neither experienced vestibular problems. By day 3 the feelings had considerably lessened, and by day 4 they had fully adapted to their weightless condition.)

The cosmonauts, with the call sign of Elbrusy, turned in for their first sleep in space at 1900 after the first manoeuvres that would lead to the docking with Salyut 7 the next day. They were awake at 0045 on the 14th and by their 11th orbit of the Earth had completed checks of their radio guidance system and reset the docking unit probes. By 0800 Soyuz T-5 had completed 14 orbits and the cosmonauts were ready for the final series of rendezvous manoeuvres. The docking occurred at 1136 with the forward docking unit of the space station. (Western reports suggest that difficulties were encountered during the docking because FCC was reported as saying that "they had lived through the docking with the cosmonauts").

The Elbrusy entered Salyut 7 some three hours later and began activating the station in preparation for their long stay.

Activating the Station

The first work included activating the life-support system, the water recovery system (which condenses atmospheric moisture) and the power supply systems. The workload was kept light to avoid tiring the crew. As soon as the Salyut's life-support systems were working the cosmonauts powered down the Soyuz T-5 ferry and installed on air hose to help the flow of air between the vehicles.

A day after the docking, TASS announced the orbital parameters of the complex as: 343×360 km; period 91.3 minutes; inclination 51.6 degrees. Inside the station the temperature was 20 degrees C, and the pressure 840 mm of Mercury.

FCC had allotted three days for getting Salyut 7 into working order. The cosmonauts were scheduled next to prepare the scientific equipment, much of which was rigidly bolted down to protect it from the stresses of launch. They loaded up the fixed and portable cameras with film and made a start on their regular sessions of physical exercises on the KFT treadmill and veloergometer. The scientific research was scheduled to begin only one week after their launch.

The Soviets described Salyut 7 as being the same size and shape as the Salyut 6 station, with two docking units, the major differences being in the composition of the scientific experiments. Future Mission Reports will carry descriptions of this research equipment.

A Unique Experiment

On 17 May, to coincide with the opening in Moscow of the Young Communists League Congress, Berezovoi and Lebedev launched a sub-satellite.

The Iskra 2 satellite, a 28 kg hexagonal communications relay satellite, was put into the ShK airlock and, following evacuation of the air in the chamber, simply jettisoned into outer space. The technique had been used before for ejecting waste bags.

Iskra 2 was constructed by students from the Sergei Ordzhonikidze Aviation Institute in Moscow (Lebedev is a graduate) and was designed to provide communication between radio hams and student organisations from the USSR and Soviet-oriented countries. It contained a repeater, a radio command and memory unit, a command radio channel and a telemetric system. The exterior was covered with emblems of the youth leagues of all the socialist countries.

Control was handled from centres in Moscow and Kaluga. The satellite was tracked as being in a 342×357 km, 91.3 minute orbit shortly after its "launch" from Salyut 7.

Progress 13 is Launched

On 21 May the Elbrusy commanded the Delta autonomous navigation system, which the Soviets called the central control of Salyut 7, to put the station into a gravitationally-stabilised mode. The manoeuvre, which would have normally required the crew to conduct several thruster firings, was achieved automatically for the first time. Much of the responsibility for control of the station and its systems has been passed over to the Delta system.

In this stabilised mode the cosmonauts were able to conduct extensive Earth observations. During the early part of their flight they reported two large cyclones over the USSR and photographed the Krasnodar territory, the main winter granary in the USSR, cotton fields in Central Asia and crops around the River Volga.

At 0557 on 23 May the Soviets launched the 13th in the series of Progress automated transport ships to deliver supplies and further equipment. From its initial low orbit of 191×278 km, Progress 13 was manoeuvred over the next two days to a successful docking with the aft port, at 0757 on 25 May.

In its two compartments, with a volume of 6.6 m³, there was about 2100 kg of equipment and supplies, including 660 kg of fuel for the ODU, 290 litres of water, almost 900 kg of scientific equipment (including about 250 kg for the Soviet/French flight), and food and clothing. Specific items of scientific equipment included a new, improved, Kristall unit for technological experiments, an EFO-7 electrophotometer designed for stellar studies, and the French Posture and Ecography experiments.

On 26 May the cosmonauts opened the hatch between the two craft and began unloading with their first priority being a parcel of food, gifts and letters from their families and friends. The refuelling of the ODU was completed by 1 June and water from the Progress external tanks was transferred into the Salyut external tanks via the Rodnik (Spring) pumping system.

Making Ready

On 2 June Salyut 7 was, using the propulsion unit of Progress 13, manoeuvred into an orbit below its operational height. The three-spacecraft complex was lowered to 291×321 km in a two impulse manoeuvre from the 335×341 km orbit it had occupied. It might be, as P. S. Clark has speculated, that the three man version of Soyuz T (as was to be used in the French flight) is unable to reach the normal 350 km orbit of Salyut 7. Clark notes that the three man Soyuz T-3 flight in November 1980 flew into a similar orbit.

At 0631 on 4 June Progress 13 was undocked and steered away. At 0005 on 6 June the propulsion unit was used to send the discarded ship, laden with rubbish, into the atmosphere over the Pacific Ocean where it was destroyed away from shipping lanes.

On 19 June the complex was given a final correction to refine its groundtrack in readiness for the launch some five days later of the Soviet/French Soyuz T-6 spacecraft.

To be continued

JOHN YOUNG – ONE MAN'S CONQUEST OF SPACE

PART TWO

By David J. Shayler

In the introduction to the first part of this biography of astronaut John Young, published in the May 1982 issue, the prediction was made that he was looking for a record sixth space flight. Since then, of course, it has been announced that Young will command the important Spacelab 1 mission in September 1983.

This part of the biography deals with the Gemini phase of his career. Unless he retires soon, we will have to extend the series into the next decade!

Introduction

As 1963 dawned, the Mercury age was drawing to a close and NASA was already preparing for the next stage. Gemini was then planned for 1964–66 with ten manned missions. For Young and his fellow class 2 astronauts, the preparations began late in 1962 with formal lectures and demonstrations. In January 1963 he was involved with environmental control systems, pressure suits, survival and other associated pilot equipment [1]. Over the next 16 months, Young's training included classroom lectures by specialists and briefings by the spacecraft manufacturers. There was also the dreaded "week in the barrel" tour of talks to audiences ranging from young school children to senior citizens. Young enrolled in Toastmasters International to help him prepare the speeches he had to make.

Classrooms, Deserts and Jungles

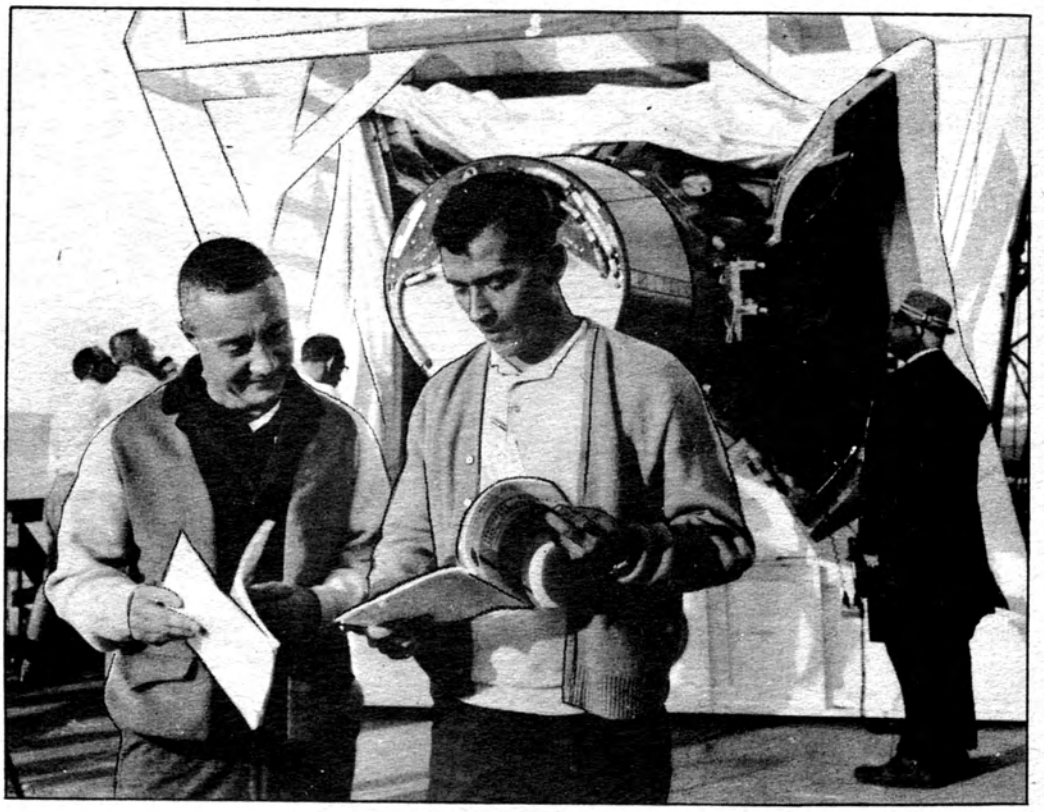
Throughout 1963 and early 1964 Young was taking courses in geology, astronomy, astronautics and flight dynamics. In addition, he kept himself physically fit by exercising in a gym, usually in a pressure suit (minus helmet and gloves), and by jogging. His flying proficiency was maintained with the jets made available to all the astronauts. Like the others, he enjoyed the friendly rivalry within the team. He was possibly one of the first [2] to fly non-stop between Los Angeles and Houston in a T-38 jet, a distance beyond the designed fuel capacity.

During his training, Young undertook survival courses in some of the most inhospitable places on Earth. Desert survival training was conducted at Carson Sink in Nevada [3], where the astronauts learned to cope with the harsh conditions. During a course near Stead Air Force Base he was stung in the ankle by a scorpion. Refusing the help of the accompanying medics, he took care of the wound himself, saying that he would be unlikely to find any convenient help in the Sahara if his spacecraft landed there [14]. A course was also taken in survival in tropical rain forests.

Weightless training was done in aircraft following parabolic paths. Young described his experience of this as "something like swimming ... except that here, with nothing to push against, you just hang there until the plane pulls out of its trajectory" [5]. Young decided that he had moved into the right career: "I can't think of another single job I'd rather have – in this world or out of it" [6].

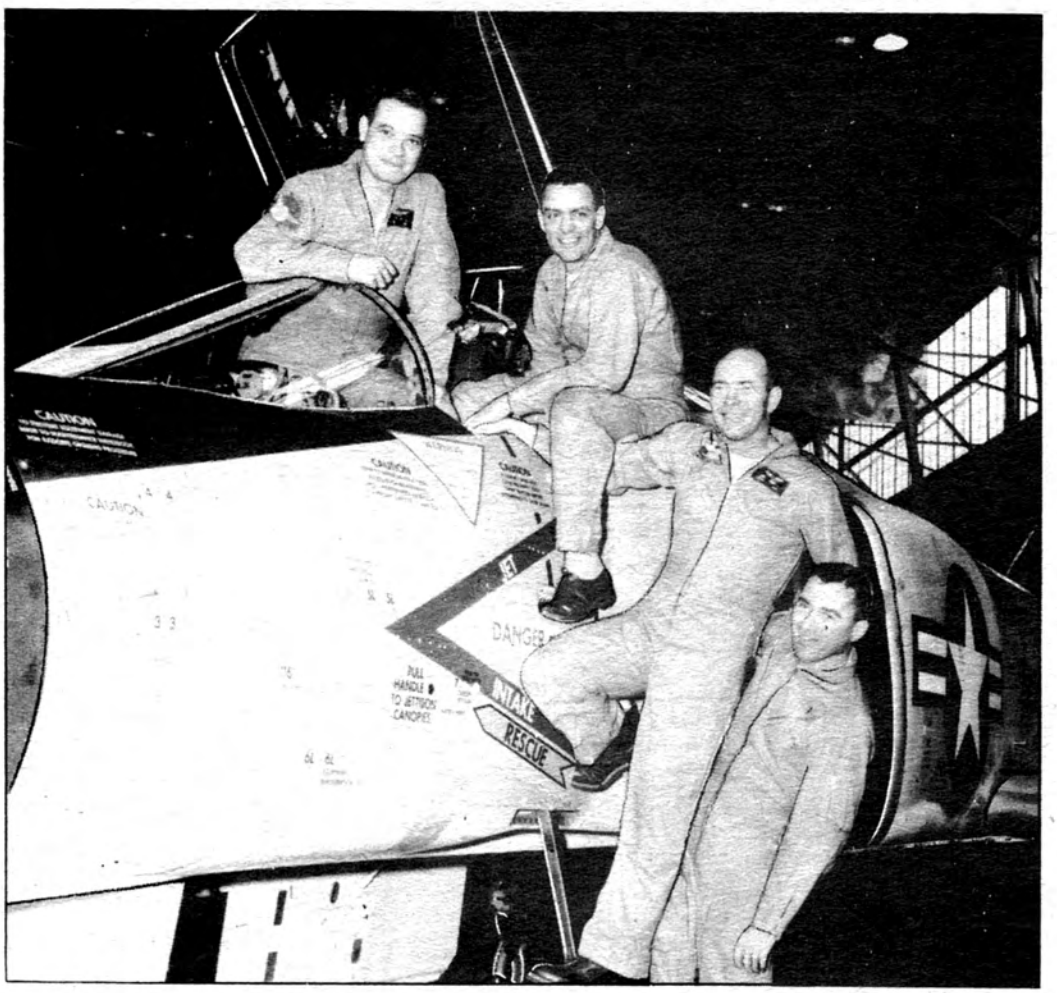
In addition to general training, he undertook several assignments for the development of the Gemini and Apollo spacecraft. These included a study to see if an astronaut could control the Lunar Module rendezvous manually with the command module if the LM's primary guidance system failed during the descent [7]. In October 1963 he was involved in

Young and his fellow new astronauts were presented to the press in Houston on 17 September 1962. On the 19th he returned (pictured here) to Miramar in California before finally leaving the following month.



Young and Grissom discuss the day's work before beginning a communications test with the Gemini 3 spacecraft at the Merritt Island Test Area.

NASA



Young (right) shortly before entering the record books as part of Project High Jump (see the May 1982 issue, p. 223). Days before – this picture is dated 27 February 1962 – his interest in space travel had been roused by Glenn's orbital Mercury flight.

US Navy

tests to see how easy it was to climb out through the CM hatch wearing a full suit and backpack. The severe difficulties discovered had to be solved before such attempts were made in space [8].

Training for Gemini 3

On 13 April 1964 NASA announced the names of the four astronauts assigned to the first Gemini mission. Virgil Grissom was to be the commander, with Young as his pilot. The backup crew were Wally Schirra and Tom Stafford [9].

For the next two months, Young and Grissom spent some 36 hours in the Gemini simulator, although it was not yet an exact copy of their flight vehicle [10]. The simulator was rebuilt more accurately at Houston, and the crew began simulations again in November. On 19 May 1964 the Manned Spacecraft Center began a ten day series of short weightless tests with the Gemini spacecraft installed inside a KC-135 aircraft. Young took an active part, along with four USAF and McDonnell test pilots [11].

The gaps between assignments were bridged by averaging at least 25 hours a month flying and 200 hours in classroom briefings. Seminars were held with some of the country's leading space scientists [12].

During October and November 1964 Young and Grissom spent 14 hours in the Gemini 3 cockpit. During the course of altitude tests, they pressed McDonnell to allow them to depressurise the spacecraft and open a hatch at a simulated altitude of 46,000 m. Young managed to open the hatch but had extreme difficulty closing it again, highlighting a problem that would have proved very dangerous if carried out in space. No EVA was planned for Gemini 3, but the efforts of the first crew were rewarded by Gemini 4 the following year.

In October the crew also began rehearsing evacuation of their spacecraft after a water landing. The training progressed in careful stages. First they tried it out on dry land, followed by work in a swimming pool. Finally, in February 1965, the fully suited astronauts used a boilerplate spacecraft in the Gulf of Mexico, moving to their one-man life rafts in a choppy sea.

On 9 December 1964, Young was in the Mission Control Center at the Cape when the Gemini 2 launch was aborted because of a launcher hydraulic problem. He was there again on 19 January 1965 to witness the countdown and successful launch of Gemini 2 from pad 19.

That same month, the crew went to Dallas for abort simulations. The prime method of spacecraft evacuation in the event of a launch failure, or of landing difficulties, was by ejector seat. During one of these tests the spacecraft hatch failed to open, forcing the seat to plough through it, an event which Young witnessed, and which he later said would have caused "one hell of a headache – but a short one" [13]. At the end of the series Young had run through a total of 154 abort modes. In the course of this month the crew also undertook a refresher course in parachute landings over land and sea.

By the end of the training programme the crew had spent some 35 hours in the flight spacecraft they were to fly for only four and a half hours. By early March 1965 the crew were adding the finishing touches to their training and preparations for the mission.

The Launch

Originally scheduled for launch in 1964, technical problems forced a rescheduling of Gemini 3 to 23 March 1965 [14]. On 21 March Young and Grissom went through a full physical examination . The day before the flight was spent relaxing and reviewing the flight plan, before going to bed at 9 that evening.

They were awakened at 4:40 the following morning by the Assistant Director of the Manned Spacecraft Center for Flight Operations, Deke Slayton. By 5 am they had left the sleeping quarters and undergone a ten minute final physical examination. This was followed by breakfast in the crew quarters with 12 invited guests. They left the building at 5:53 for the six mile trip by car to the suiting-up trailer at pad 16. The biomedical sensors and communication equipment were thoroughly tested, and oxygen was pumped through the suits to purge them of nitrogen to prevent "bends" during launch. Schirra and Stafford had been in the spacecraft since 3:00 am, checking the flight controls, communication links and setting the switches in their launch positions.

By 7:12 am they had entered the spacecraft after the short trip to pad 19, with Young on the right and Grissom on the left. They performed the prelaunch checks so efficiently they found themselves 20 minutes ahead of schedule. At four seconds past 9:24 am on 23 March 1965, the engines of the Titan II roared into life. Launch CapCom Gordon Cooper informed the crew, "You're on your way Molly Brown" [15], and the seventh American astronaut crew left the Cape to the cheers of the spectators, including fellow astronauts, friends and both astronauts' wives [16].

The second phase of America's manned space programme was underway. For Young, at the age of 34, the launch must have been one of the most thrilling moments of his life.

To be continued

Acknowledgements

In addition to those acknowledged in Part I, the author wishes to thank the following for their assistance in the preparation of this series: Robert A. Carlisle, Still Photo. Branch, Dept. of the Navy, Office of Information, Washington, for supplying the photographs on Project High Jump; Anna C. Urband, Dept. of the Navy, for details of Young's naval career; and Robert J. Howard, Information Manager, *Sentinel Star*, Florida, who provided additional information from Orlando newspapers.

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RESEARCH FROM SOVIET SATELLITES

THE "HIDDEN" SIDE OF SOVIET SPACE RESEARCH

By Joel Powell

Many Soviet scientific and supplemental space missions remain unidentified until the scientific results are published, usually years later. Here the author looks at the specific missions of some of these Soviet launches.

Cosmos Satellites

At least two Cosmos missions in the last decade suspected of being scientific flights were not identified in the literature until after the satellite launch compilations were published. Perhaps fearing embarrassment if no scientific findings resulted from an announced mission, the Soviets concealed the exact purpose of Cosmos 426, and other satellites, until several years later.

Radiation research was conducted by Cosmos 426 (1971-52A): the angular distribution of electrons with energies greater than 20 keV was measured by the UER-1 instrument, and the TEP-3 semiconductor detectors measured the spectrum of Van Allen belt protons and electrons, as well as solar cosmic rays. Galactic cosmic rays were detected by the KL-2 gas discharge counters [1].

A more recent mission recently revealed in the literature is Cosmos 906 (1977-31A). One of the instruments carried was a newly developed miniature proportional counter to measure charged particles. The device had also flown on Cosmos 484, Intercosmos 13 and 17, and Prognoz satellites [2]. The Cosmos 906 mission may have been related to the dedicated magnetospheric satellite Cosmos 900.

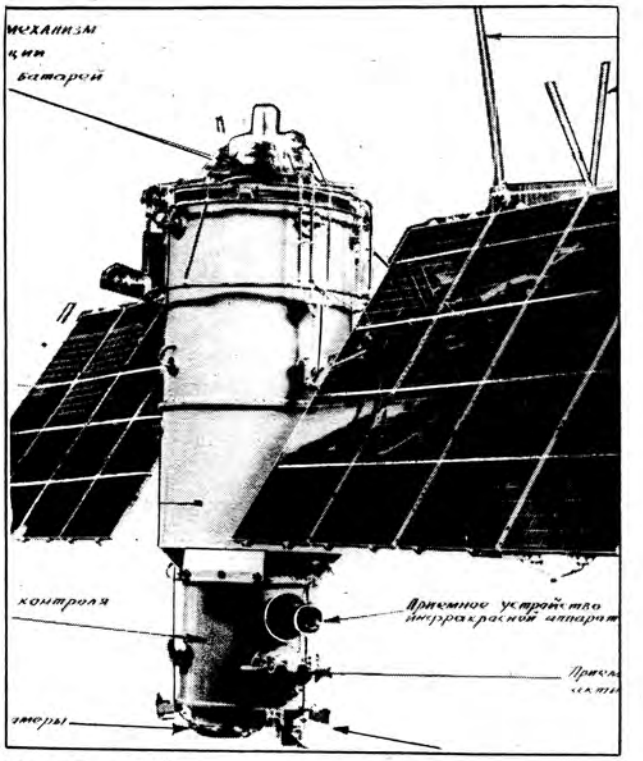
Many Cosmos reconnaissance satellites also carry supplementary add-on scientific payloads [3]. See Table 1. Several noteworthy missions in this category have been revealed recently. The submillimetre radiometer carried by Cosmos 669 was a liquid helium-cooled device built by the Lebedev Physical Institute of Moscow to investigate the upper atmosphere water vapour content and the mean atmospheric brightness of cloudless land regions. The "Obzor" radiometer worked in the 60-130 and 350-650 μm bands [4,5].

The micrometeorite detectors carried by Cosmos 470, 502 and 541 may have been part of an extensive micrometeorite investigation carried out by the Soviets a decade ago. The investigation also included the Salyut 1 manned space laboratory, the Vertical 1 rocket and the Vostok-type Intercosmos 6 spacecraft.

Cosmos 650 (1974-28A) was a "possible navigation-geodetic satellite" carrying an add-on payload to measure solar protons simultaneously with an unspecified Molniya communication satellite. Soviet non-reconnaissance satellites rarely carry supplemental scientific payloads.

Table 1. Cosmos satellites' scientific payloads.

Number	Designation	Payload type	Notes
Cosmos 426	1971-52A	space science	see text
Cosmos 470	1971-118A	add-on	luminescent and capacitive micrometeorite detectors [6]
Cosmos 502	1972-55A	add-on	luminescent micrometeorite detector [6]
Cosmos 541	1972-105A	add-on	same as Cosmos 470 [6]
Cosmos 555	1973-24A	add-on	electron and solar cosmic ray (protons) detectors [7]
Cosmos 650	1974-28A	add-on	solar protons [8]
Cosmos 669	1974-59A	add-on	submillimeter radiometer
Cosmos 721	1975-20A	add-on	auroral electrons and Van Allen belt protons [9]
Cosmos 731	1975-41A	add-on	astronomical gamma-ray telescope [10]
Cosmos 782	1975-110A	add-on	cosmic ray spectra [11]
Cosmos 906	1977-31A	space science	see text



Meteor-type satellite.

One aspect of the Cosmos 213 mission (involved in the second Soviet unmanned Soyuz docking in April 1968) has been ignored in published accounts of the feat. An extensive scientific payload was carried, including a new type of luminescent micrometeorite detector [12], an ultraviolet photometer similar to that aboard Cosmos 51 and a radiation sensing package. The photometer measured UV and visual spectrographic night sky brightness [13] and cosmic ray positrons and electrons were measured by the "Ray-1" apparatus. A cryogenic superconducting magnet (first tested on the Cosmos 140 Soyuz precursor) aided the detection of cosmic rays by the associated scintillation, gas discharge and Cerenkov detectors of the experiment [14].

The Zond 8 lunar spacecraft (1970-88A) also carried a scientific experiment. Unshielded aluminium foil "targets" similar to the Apollo lunar surface solar wind collectors were mounted on the outside of the command module, to detect the isotropic composition of the solar wind [15].

Communications Satellites

Soviet space scientists have long been able to take advantage of the Molniya communications satellites' unusual orbits (40,000 × 700 km, about 65° inclination) to fly radiation sensing payloads, in the same way that American scientists fly "environmental monitoring packages" on civil and military weather satellites.

The vast majority of Molniya instruments revealed in the literature are particle detectors, the type varying from flight to flight. Table 2 suggests that all Molniya I's (or at least those

Table 2. Molniya satellites' scientific payloads.

Number	Designation	Notes
Molniya 1-5	1967-52A	geiger-muller counter, ionization chamber [17]
Molniya 1-14	1970-49A	ionization chamber [17]
Molniya 1-15	1970-77A	ionization chamber [17]
Molniya 1-16	1970-101A	phoswich neutron monitor, IK-4 ionization chamber, omnidirectional scintillation detector [18,19,20]
Molniya 1-17	1970-114A	ionization chamber, omnidirectional scintillation detectors [21,22]
Molniya 1-19	1971-115A	Cerenkov detectors [23]
Molniya 1-21	1972-81A	Van Allen belt electron spectrometer [24]
Molniya 1-23	1973-07A	semiconductor proton spectrometer for comparison with ground measurements [25]
Molniya 1-24	1973-61A	semiconductor proton detector, continuous recording [26]
Molniya 1-27	1974-23A	magnetospheric variations; electron spectrometer and cylindrical electrostatic analyser [27]
Molniya 2-14	1975-81A	SPA proton spectrometer and separate DP-30 proton detector for higher levels [28]
Raduga	1977-71A	ZK-72 proton detector (up to 130 MeV) [29]

since 1970) are instrumented, but mentioned in the literature only when new scientific information is gathered. (Results from later than 1975 have yet to be published for Molniyas.) Proton and electron detectors predominate, with the occasional ionization chamber noted. Molniya 1-16 carried a neutron monitor and Molniya 1-19 had a Cerenkov detector for cosmic ray studies in conjunction with a similar devise on the Mars 2 probe. Only one Molniya 2-type spacecraft has scientific instruments identified with it so far.

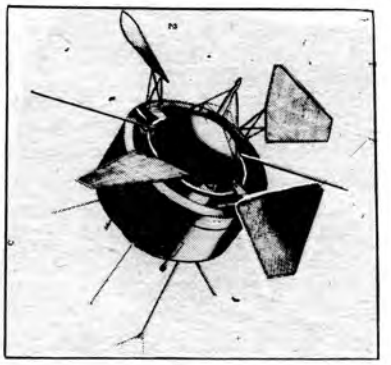
Raduga-type (Statsionar) geostationary orbit communications satellites also carry instruments, with one spacecraft so far being identified. The spacecraft have also been reported as carrying electron detectors to study "plasma layer electrons" at synchronous altitude [16].

Meteor Satellites

Although fairly numerous descriptions of the Meteor meteorological satellites' instrumentation and cameras exist, very few of the spacecraft have been recorded as carrying scientific research apparatus. The ion mass spectrometer of Meteor 1-25 (see Table 3) is one of the few such devices in the supplementary instruments area. The Geiger counter carried on Meteor 1-22 also seems rarely mentioned in the Soviet literature. The Sun-synchronous polar orbits used by weather satellites are ideal for monitoring radiation fluxes in the lower radiation belts (and have been monitored by every such American meteorological satellite since ITOS-1 in January 1970) and it can be assumed that the Soviets extensively exploit the Meteors for this purpose.

Table 3. Meteor satellites' scientific payloads.

Meteor	Designation	Notes
Meteor 1-22	1975-87A	SBM-10 geiger counter to measure Van Allen electrons and cosmic ray flux [30]
Meteor 1-25	1976-43A	MX-6407 ion mass spectrometer; SI-1 Fourier IR spectrometer (GDR) [31,32]
Meteor 1-28	1977-57A	SI-1 Fourier IR spectrometer (GDR) [32]



Proton 1 was launched in July 1965 to investigate high energy cosmic rays.

The East German experimental infrared Fourier spectrometers carried by Meteors 1-25 and 1-28 represent on-orbit testing of new instruments for weather observation. This parallels work performed by the American Nimbus satellites since 1964. In both cases, atmospheric sounding apparatus is first tested and perfected in space before being added to the complement of operational instruments.

Conclusions

There is an indication that the Soviets seem to have abandoned their national radiation research programme with satellites in low Earth orbit in the early 1970's, except for the international Intercosmos satellites. This work has been transferred to supplemental payloads almost exclusively (Cosmos 906 appears to have been a recent exception). Their space science emphasis is now on high altitude, magnetospheric research with the Prognoz spacecraft and single missions such as Cosmos 900 and Arcad 3 (Oreol 3). Even the Intercosmos series has shifted in emphasis towards more practical applications such as ocean monitoring and remote data gathering.

Compiling lists of the missions of supplemental and previously unknown Soviet missions not only helps to fill in the gaps on the launch roster but it can also help to illuminate the direction of Soviet space science research.

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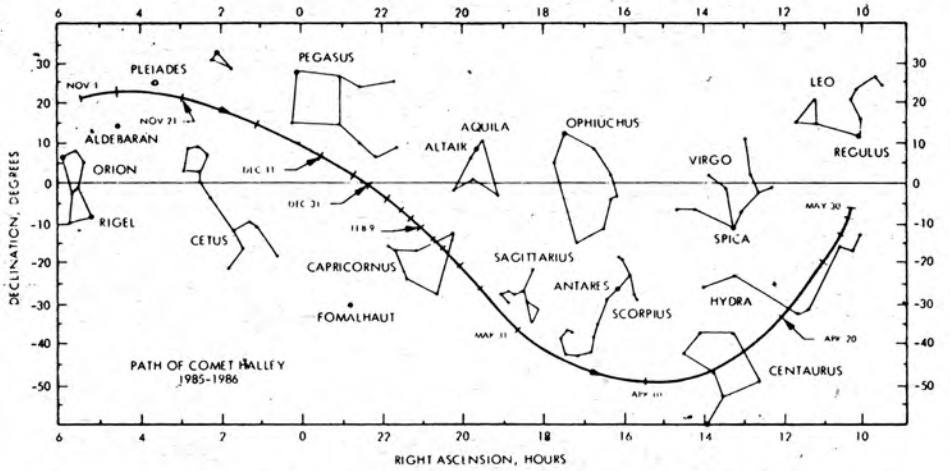
Society Educational Tours

Halley's Comet – April 1986 – 14 days duration



Owing to the likelihood that Halley's Comet will prove to be a disappointing object when viewed from the Northern Hemisphere, if it can be seen at all, the Society plans to organise a trip to South Africa to view the comet from the Southern Hemisphere. Present indications are that the most favourable time will be the first week in April 1986.

The provisional itinerary is: flight from London to Johannesburg, four nights in Johannesburg, three day tour of Kruger National Park, flight to Port Elizabeth, three day tour of the Garden Route from Port Elizabeth to Cape Town, four nights in Cape Town, and return to London *via* Johannesburg. There will be plenty of opportunities for viewing the comet.

The approximate cost at present day prices is £1000. This includes all air and coach travel, accommodation in first class hotels, plus breakfast and dinner on coach-travelling days.

We hope to provide each participant with a copy of a Society booklet (provisionally entitled "Halley's Comet Excursion") containing a history of previous Comet apparitions, with space for observations and personal notes about the expedition itself, together with star maps and other details of the 1986 return.

Forms for provisional registration are now available from the Executive Secretary. Please enclose a stamped addressed envelope.

A deposit of £30 per person is required, fully refundable on written cancellation at any time up to December 1985.

Photography expert Douglas Arnold writes:

The pre- and post-perihelion closest approach of the comet to Earth will occur on 27 November 1985 and 11 April 1986 at distances of around 0.62 and 0.42AU, say 57 million and 39 million miles, respectively (somewhat further away than the 3 million miles or so of the AD837 visitation!).

Donald Yeomans of the Jet Propulsion Laboratory predicts that during the period around the 11 April 1986 closest approach Comet Halley will be reasonably bright and high overhead in the southern hemisphere, though invisible from northern Europe. Hence the wisdom of the BIS in planning the trip to southern climes to observe the famous visitor.

Photographically, the Comet will obviously be a teaser. If the predicted visual magnitudes are at all accurate then 400ASA colour and black and white film will be a must. If a comet is very bright you can usually start an exposure programme of from about 1/60 second up to perhaps 2 minutes with a moderate aperture of around f2.8. Star trails occur with the longer times and by two minutes the comet head is beginning to blur. But this is all theoretical anyhow if the gloomy forecasts for Halley are correct. A guided camera will be required, whether piggy-backing on a 'scope or on a drive in its own right. Choice of focal length and optimum aperture for photo lenses will have to wait on the actual event so a good complement of equipment is indicated. Despite the use of 400ASA speed films exposures of anywhere from 2 minutes up to perhaps 20 minutes will be required.

Even if the gloomiest predictions are fulfilled (and my hope is that if the experts can be as wrong with Kohoutek one way, they can be as wrong with Halley 1986 in the other) I've no doubt some splendid images will be secured, particularly "down south". But it will require (in no order of priority) – (a) a fair amount of expenditure; (b) much patience; (c) plenty of film; (d) flexibility in focal lengths available; (e) drive capability for lengthy exposures.

I hope to be there – the best of British luck to us all!

THE TITAN LAUNCH VEHICLE FAMILY

By J. G. Davies

Introduction

During the 1950's the cold war between the United States and the Soviet Union was at its height. Work had already started on developing the United States' first ICBM (Inter-Continental Ballistic Missile), the Atlas; but progress was slow. Because of the urgent need to acquire a large missile, the United States Air Force (USAF) decided to start work on a new missile. In 1955 the Martin Company was awarded a contract to design and develop a two-stage liquid propellant rocket. Taking its name from Greek Mythology, the giant rocket was named after the children of Uranus and Gaea - Titan.

Titan I

Titan got the go-ahead in 1957, and by late 1958 it was ready for ground tests. Titan I was a 100 t (98.4 ton) missile, 27 m (88.6 ft) tall and 3.05 m (10 ft) in diameter. It used liquid oxygen and RP-1 (Kerosene) in both stages. The first stage carried two Aerojet-General LR-87 engines, giving a combined thrust of 136 t (300,000 lb). The second stage used a single Aerojet-General LR-91 engine, with a thrust of 36 t (80,000 lb).

The first successful attempt at launching Titan I came on 6 January 1959 using an inert second stage. Titan I eventually entered service with the Strategic Air Command in April 1962. However, Titan I saw only three years of service before being replaced by the Titan II.

Titan II

As far back as mid-1959, the disadvantages of using non-storable propellants were being discussed. Like the Atlas, Titan I had to be set up from its horizontal before it could be fuelled and launched. This did not meet the requirements for a strategic ICBM. What was required was a retaliatory weapon that could withstand a pre-emptive attack of severe bombardment - an ICBM with storable propellants and launched from an underground silo.

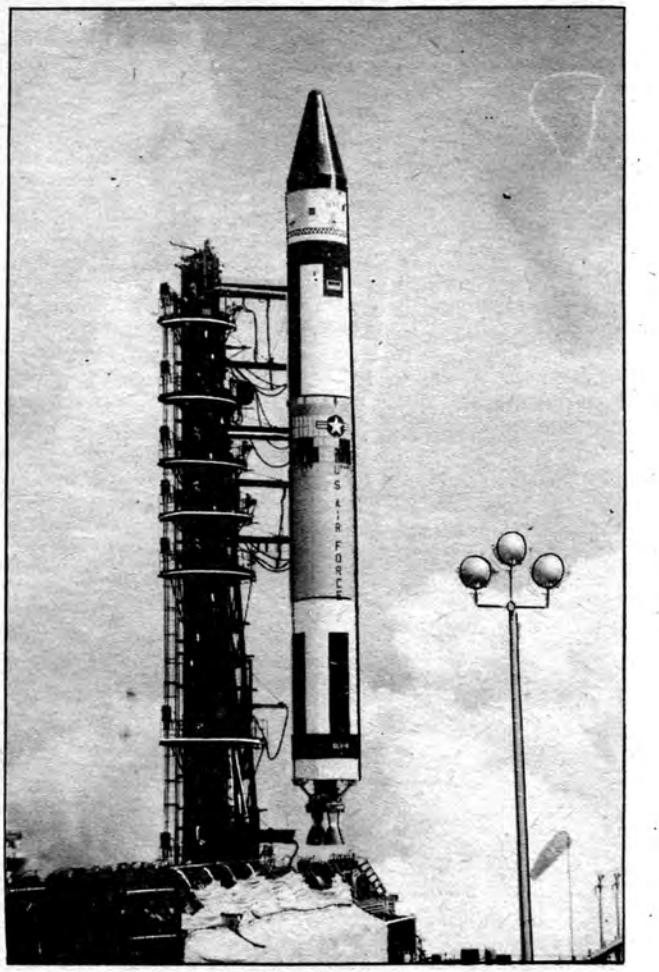
Considering these requirements, the decision was made to expand the promising technology of Titan I and use it as a basis for a new version: Titan II. Development began in June 1960.

Titan II was a two stage missile 3.05 m (10 ft) in diameter and 31 m (102 ft) tall, of which 21.5 m (70 ft) was the first stage. Two Aerojet-General YLR-87 rocket motors giving a combined thrust of 195 t (430,000 lb) were used in the first stage, while a single Aerojet-General YLR-91 rocket motor, giving a thrust of 45.4 t (100,000 lb) was used to power the second stage. These engines ran on storable hypergolic propellants; a blend of hydrazine and unsymmetrical dimethylhydrazine (UDMH) as fuel, with nitrogen tetroxide as oxidizer. Since this combination is hypergolic - fuel and oxidizer ignite on contact - Titan II required no ignition system. Since both fuel and oxidizer can be stored and used at normal temperatures - instead of the supercold liquid oxygen of Atlas and Titan I - Titan II needed no cold storage and handling facilities.

A total of 35 Titan II test flights were conducted, the first on 16 March 1962. After a number of problems, of which longitudinal oscillation was the greatest, Titan II was declared to be operational in December 1963. By 1965 all of the Titan I's had been withdrawn from service and replaced by Titan II and Minuteman. Today there are about 52 Titan II missiles, each carrying nuclear warheads.

Gemini

Early in 1961, at the same time that the Martin Company was developing the Titan II as an ICBM, NASA was working on an improved Mercury manned spacecraft, later to be known as Gemini. NASA began to investigate the possibilities of using the Titan II as a launch vehicle for the two man Gemini spacecraft.



Launch of the fourth Titan IIIA (May 1965).

USAF

In December 1961 NASA announced Project Gemini and the selection of Titan II as the launch vehicle. The USAF, acting as contractor, took responsibility to ensure that NASA got its Titan II launch vehicles.

Titan II was the most logical choice for Gemini because it was the most powerful and advanced rocket the United States had under development at that time and it could also be brought up to manned spacecraft launcher standard. Other factors in Titan's favour were its use of storable propellants, which made it capable of standing for considerable lengths of time on the launch pad; also the Air Force had done considerable work in designing and testing Titan as a launch vehicle for the Dyna-Soar programme.

In order to uprate it into a man-carrying launch vehicle, the USAF had to make a number of modifications. The main modifications were:

(i) a new Malfunction Detection System (MDS) and a backup flight control system,
(ii) an electrical system with backup circuits for guidance, engine shutdown, and staging,
(iii) substitution of radio guidance for inertial guidance.

The first test flight came on 16 March 1962 from the Cape Canaveral Missile Range. One and a half minutes after lift-off, when the first stage engine was still firing, the missile began to vibrate lengthwise at about 11 times a second for about 30 seconds. This trouble would not have been too serious for a missile, but in the case of a manned launcher it was dangerous. Accelerations of two and a half times that of gravity were recorded in this first flight. It took almost two years to analyse and solve the problem.

Efforts to solve the Pogo problem had been in progress since early 1962 and the problem of instability in the second-stage engine was being tackled by Aerojet-General. They began in October 1963 and 18 months later their new design for the engine was a complete success. NASA installed the new engines with modified propellant injectors in the last six Gemini launch vehicles; the previous six flew with the old style injectors.

Due to NASA's pressure, the Air Force began a drive in September 1963 to bring the manufacturing of parts up to the higher standard that NASA required. They spent $11 million on design improvements, improving welding techniques, and better assembly and quality control standards.

By the early spring of 1964, all three major problems that NASA had stated must be reduced to tolerable levels before Titan II could be fully man-rated, had been solved. In fact, the first Gemini flight occurred on 8 April 1964, the day before the Titan II research and development programme ended. It would be another year before Titan carried men. One more Gemini-Titan test flight occurred on 19 January 1965; again it was successful.

On 23 March 1965 a Titan II orbited the first manned Gemini spacecraft, Gemini 3. Titan proved itself by safely launching all ten manned Gemini spacecraft.

Titan III

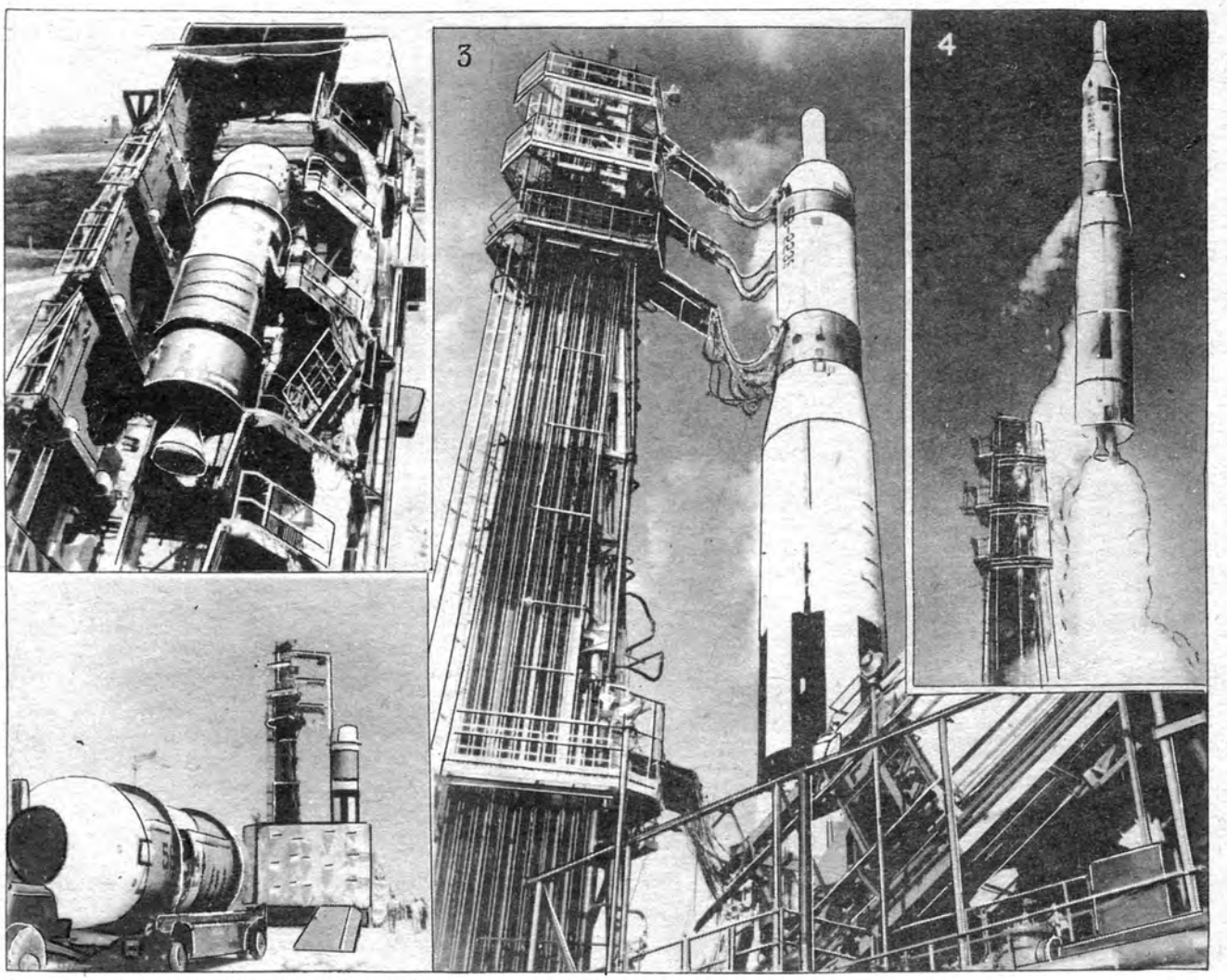
In order to follow the development of Titan, we have to return to 1962. The Air Force wanted to develop a national launch capability for a wide variety of manned and unmanned space missions. In August 1962 the Department of Defense (DOD) approved the Titan III standard space launch system.

Titan IIIA

The Titan IIIA consisted of a two stage Titan II strengthened to accommodate a third stage and heavier payload. The new stage (Transtage) used the same type of storable propellants; its diameter was 3.05 m (10 ft) and it was 4.57 m (15 ft) high, with a thrust of 7.1 t (15,600 lb). Transtage had the capability of multiple restart.

Titan IIIA stood 38 m (124 ft) tall, 3.05 m (10 ft) in diameter, and could deliver about 2.8 t (6,200 lb) into low Earth orbit.

The first IIIA was launched from Cape Canaveral in September 1964. By 6 May 1965 four had been launched, with a fifth cancelled because research and development objectives had already been met. After further development, the IIIA became the central core for the Titan IIIC.



The preparation and launching of a Titan I missile.

Titan IIIB

In July 1966, the first Titan IIIB was launched from the Vandenberg Air Force Base in California, and it became the USAF standard medium-weight launcher.

The IIIB carried an Agena D as third stage with a strengthened Titan II as first and second stages. The total height varied between 44 m (144 ft) and 52.7 m (173 ft), according to payload. It could place up to 3.5 t (8,000 lb) into polar orbit or 450 kg (1,025 lb) into geosynchronous orbit.

The Titan IIIB is presently used by the USAF for launching reconnaissance satellites.

Titan IIIC

In 1967 the Air Force introduced the Titan IIIC. Basically, it was a Titan IIIA (as a central core) plus two five-segment strap-on solid propellant boosters (stage 0) attached to the sides of the first stage. This configuration made the IIIC more than 9.1 m (30 ft) wide at the extreme.

The IIIC is capable of launching payloads ranging from 13.2 t (29,000 lb or 12.9 tons) into low Earth orbit; 1.3 t (3,000 lb) into synchronous equatorial orbit; and between 771 kg (1,700 lb) and 1,814 kg (4,000 lb) to Mars or Venus.

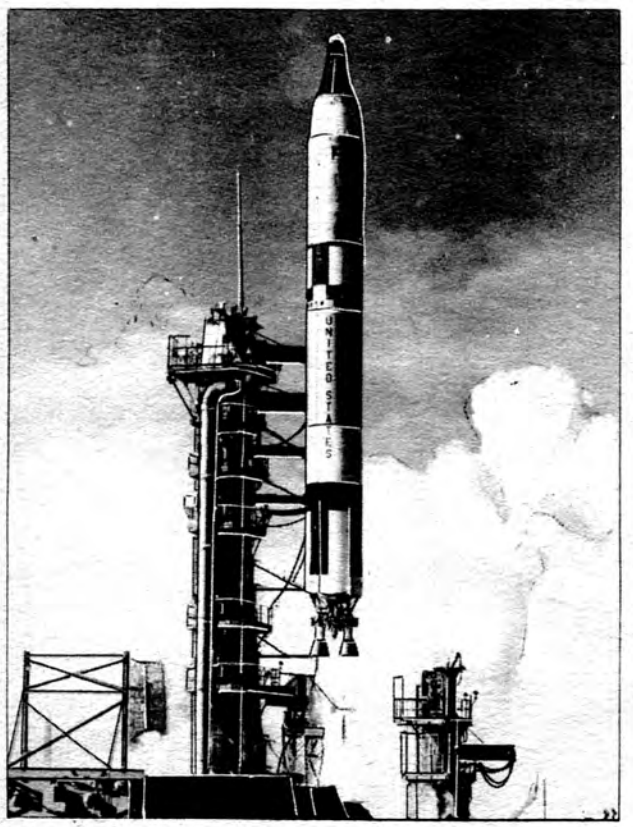
Titan IIID

The Titan IIID is essentially a IIIC without the Transtage. Payload capacity is a minimum of 13,600 kg (30,000 lb or 13.4 tons) for low Earth orbit, to 10,890 kg (24,000 lb or 10.7 tons) for polar orbit.

Like the IIIB, the IIID is launched from the Vandenberg Air Force Base and used exclusively for military space operations, launching mainly surveillance and reconnaisance satellites (Big Bird and KH-II being examples).

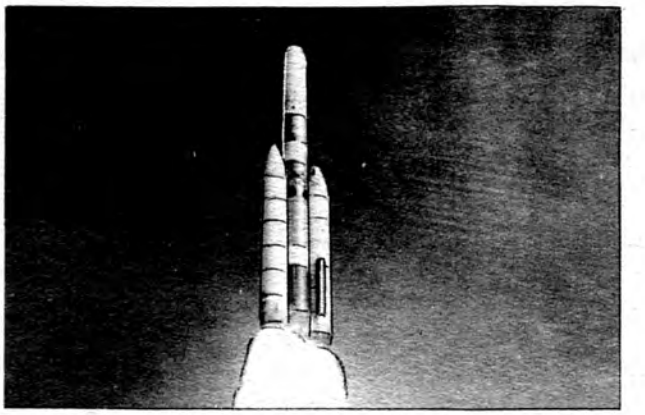
Titan IIIE-Centaur

Titan IIIE was developed for use as a civilian space launch vehicle for NASA for launching planetary spacecraft. It is basically a standard Titan IIIC, with a Centaur replacing the Transtage.



The final manned Titan II launch, carrying astronauts Lovell and Aldrin aboard Gemini 12.

NASA



Launch of the ATS 6 communications satellite by Titan IIIC in May 1974.

NASA

Its most unusual feature is its top heavy appearance. This is caused by the large payload shroud which covers both the satellite and Centaur. The main Titan "core" has a diameter of 3.05 m (10 ft), while the shroud has a diameter of 4.27 m (14 ft). Total height of the IIIE is 48.8 m (160 ft).

Titan IIIM

In 1964, the Air Force began work on a Manned Orbital Laboratory (MOL). This vehicle consisted of a modified Gemini spacecraft resting on a cylindrical space laboratory. It was an experimental programme to study the use of space for military purposes.

By 1966, the total weight was over 13,600 kg (30,000 lb) and it therefore required a more powerful booster than the Titan IIIC. The USAF decided on a modified IIIC design, called the Titan IIIM. The IIIM was to use a seven segment solid fuel strap-on booster, as opposed to the five segment booster used on the IIIC. First stage engines were to use a new 15 to 1 expansion nozzle; and there was no Transtage.

Although an unmanned test flight of a MOL mock-up (reflying the Gemini 2 spacecraft) was launched in November 1966 by a Titan IIIC, the IIIM design was never used. On 10 June 1969, MOL was officially cancelled.

Titan 34D

The Titan 34D is the latest generation of USAF Titan III launch vehicles. Apart from two main differences, the Titan 34D is basically the same design as the Titan IIIC. These two dissimilarities are that the Titan 34D,

(i) Utilises five and one-half segments solid propellant motors. This extra half segment provides an increased capability for heavy military payloads.
(ii) Uses a solid propellant Inertial Upper Stage (IUS) instead of the Transtage.

The IUS will also be used by NASA's Space Shuttle in order to take payloads into higher orbits or interplanetary missions.

Like the Titan IIIC, the Titan 34D will be used to orbit military satellites for the USAF, using Complex 40 at Cape Canaveral.

Conclusion

With the introduction of the Space Shuttle during the 1980's, the family of Titan III launch vehicles will be phased out. However, the Air Force might keep a heavy-weight space launch vehicle, such as the Titan 34D, as a backup to the Space Shuttle.

SATELLITE DIGEST – 160

Robert D. Christy
Continued from the December issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

COSMOS 1388-1395 1982-73A-H, 13375-13382

Launched: 0630, 21 Jul 1982 from Plesetsk by C-1.
Spacecraft data: Probably spheroidal in shape, around 1 m long, 0.8 m diameter, mass around 40 kg each.
Mission: To provide tactical communications between troops or units in the field.
Orbits: 1,395×1,476 km, 114.58 min, 74.02 degrees (lowest) and 1,476 × 1,517 km, 115.92 min, 74.01 degrees (highest).

MOLNIYA-1 (55) 1982-74A, 13383

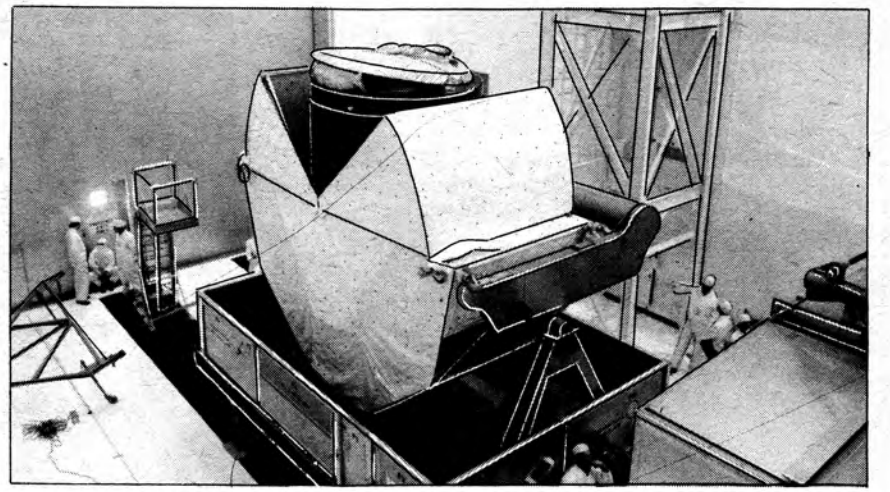
Launched: 0950, 21 Jul 1982 from Plesetsk by A-2-e.
Spacecraft data: Cylindrical body housing instrument and the payload, surmounted by a conical motor section. Power is provided by a "windmill" of six solar panels. Overall length is 4.2 m, diameter 1.6 m and mass about 1,800 kg.
Mission: The satellite helps to operate long distance telephone and telegraphic communications and broadcast Central Television programmes via the Orbita system to remote areas of the Soviet Union.
Orbit: Initially a low parking orbit and then injected into a highly elliptical one of 617× 38,917 km, 707.19 min, 62.93 degrees. Later manoeuvred to 603×39,750 km, 717.74 min, 63.07 degrees to ensure daily repetition of ground tracks.

COSMOS 1396 1982-75A, 13392

Launched: 1230, 27 Jul 1982 from Plesetsk by A-2.
Spacecraft data: Possibly based on Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6 m, diameter (max) about 2.4 m and mass around 6,000 kg.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: Initially 198×298 km, 89.47 min, 72.86 degrees then manoeuvred.

COSMOS 1397 1982-76A, 13394

Launched: 1940, 29 Jul 1982 from Kapustin Yar by C-1.
Spacecraft data: Not available.
Mission: Possibly radar calibration.
Orbit: 343×541 km, 93.38 min, 50.69 degrees.



The Anik C-3 communications satellite inside its protective unit before installation in the Shuttle cargo bay for mission 5. The unit is closed before launch to protect the satellite; in orbit the "jaws" are opened and the craft is pushed out by springs. The Payload Assist Module then ignites to begin the final step towards geostationary orbit.

COSMOS 1398 1982-77A, 13396

Launched: 1130, 3 Aug 1982 from Plesetsk, possibly by F vehicle.
Spacecraft data: As Cosmos 1396.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package, recovered after 10 days.
Orbit: 216×234 km, 89.02 min, 82.35 degrees.

COSMOS 1399 1982-78A, 13399

Launched: 1130, 4 Aug 1982 from Tyuratam by A-2.
Spacecraft data: Possibly similar to Cosmos 1396.
Mission: Military photo-reconnaissance, recovered or re-entered after 43 days.
Orbit: Initially 170×345 km, 89.65 min, 64.90 degrees then manoeuvred several times.

COSMOS 1400 1982-79A, 13402

Launched: 0700, 5 Aug 1982 from Plesetsk by A-1.
Spacecraft data: Possibly based on the Meteor satellite body with a cylinder carrying two Sun-seeking solar panels. Length about 5 m, diameter about 1.5 m and mass around 2,000 kg.
Mission: Electronic reconnaissance.
Orbit: 630×654 km, 97.57 min, 81.16 degrees.

SOYUZ-T7 1982-80A, 13425

Launched: 1712, 19 Aug 1982 from Tyuratam by A-2.
Spacecraft data: Standard Soyuz-T design consisting of a near-spherical orbital compartment, conical re-entry module and cylindrical instrument unit. Length about 7.5 m, max diameter 2.2 m and mass around 6,500 kg.
Mission: Replacement ferry vehicle for resident crew of Salyut 7. The Soyuz-T 7 crew of Leonid Popov, Alexander Serebrov and Svetlana Savitskaya (the second woman cosmonaut) returned to Earth in Soyuz-T 5, landing at approx 1500, 27 Aug 1982.
Orbit: Initially 228×280 km, 89.5 min, 51.6 degrees then manoeuvred to the Salyut operating height of 289×299 km, 90.34 min, 51.63 degrees before docking on 20 Aug.

COSMOS 1401 1982-81A, 13427

Launched: 0950, 20 Aug 1982 from Plesetsk, possibly by F vehicle.
Spacecraft data: As Cosmos 1396.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package, recovered after 14 days.
Orbit: 261×274 km, 89.89 min, 82.33 degrees.

SOCIETY NEWS

MORE SOCIETY VISITORS

A recent visitor to our headquarters was Roy Gibson, busily commuting between offices in the UK, Germany and France and stopping on the way to discuss our Space '82 arrangements, since he was to be one of the Chairmen.

Roy's involvement with the European Space Research Organisation (ESRO) goes as far back as 1967, when he was the "No. 2" of the European Space Technology Centre. At that time ESTEC was housed in the University of Delft. He tells us that, when he first arrived, his Secretary showed him a filing cabinet in a cupboard in the University which contained "all the ESRO files". When the cupboard was opened, all the files tumbled out into the corridor. This, he has referred to wryly ever since, was the original ESRO skeleton in the cupboard!

Roy spent four years building up the ESTEC team before moving over to Paris to become the Director of Administration in 1970. He tells an interesting story about how ESRO found its HQ building: they were discovered, literally, by walking around Paris one day, in just the same way as we found our own BIS HQ. The whole thing was purely fortuitous. Although there had been initial pressure to set up the HQ in a number of different places, Paris finally won the day.

In 1975 ESRO became the European Space Agency, with Roy as its first Director-General. He is now an aerospace consultant.

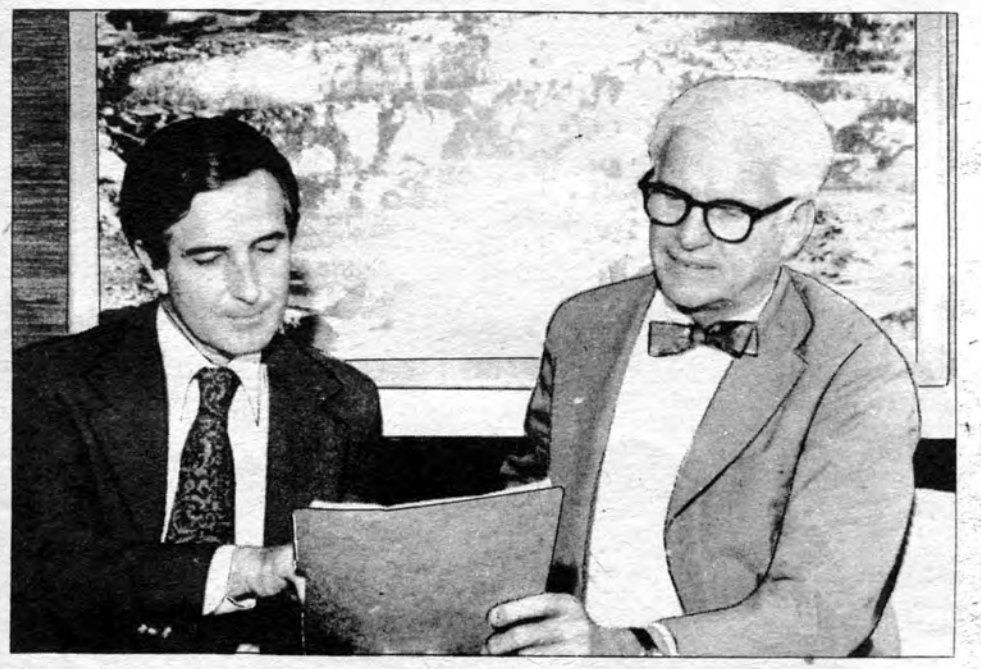
On her first trip to the UK, and with a visit to BIS HQ as a major stop, was Marcia Smith, a specialist in aerospace and energy for the Science Policy Research Division of the US Congressional Research Service. Marcia has a particularly interesting job. She has to undertake the research needed to provide individual briefings and reports to both Congressmen and Congressional Committees on all matters concerning space. This means she has to walk a perpetual tightrope in providing well-informed yet completely unbiased information.

Before working for the US Congress, Marcia worked at the AIAA Washington Office. She is proud of her UK connections, pointing out that her family on her father's side came over in the "Mayflower". By a strange quirk of fate, the relatives of Charles Sheldon, with whom she worked very closely for many years, came over on the same ship!

After attending the Paris Congress, Marcia planned to go onto New Delhi to give talks on the US Space Programme, particularly its international aspects, as part of the US involvement in the Indian 25th Anniversary Celebration. Her com-

Roy Gibson, then Director-General of the European Space Agency, signs the Memorandum of Understanding stating the terms of cooperation with NASA on the Space Telescope project (October 1977). NASA Administrator Robert Frosch sits at left.

ESA



Fred Ordway (see the continuation of "More Society Visitors" on the following page) paid the BIS a visit on his way to the Paris IAF Congress. Fred is seen here with the then Administrator of the Energy Research and Development Administration, Dr. Robert Seamans.

panion in the task was astronaut John Creighton, from the class of '78.

Fred Ordway, also on his way to the Paris Congress and busy renewing old acquaintances, took the opportunity to celebrate 30 years as a Fellow of the Society in a number of tangible ways. First he provided additional text for publication on his wonderful collection of space books and, secondly, presented our Library with a number of volumes which had featured high in our "Wants" list.

Fred's own collection of books is probably one of the most valuable existent today. It is the result of almost a lifetime's dedication. Many of his most valuable items were acquired during the decade to the mid-1950's, adding up eventually to a total stock running to about 10,000 books, major reports, photographs and paintings. The latter includes no less than 50 Chesley Bonestell originals. The Alabama Space and Rocket Center is making a cassette with 40 slides on these, alone. Fred was also instrumental in buying up the collection of the late Willy Ley, now held by the University of Alabama in Huntsville.

Fred became active in Society affairs in the 1950's when Technical Adviser to "2001 - A Space Odyssey". He tells us that Vol. 5 of the AAS History Series, out soon, contains a long piece on his activities working on the film.

Much of his work was done in collaboration with the late Wernher von Braun. One of the anecdotes he loves to recall concerns a visit by von Braun during the hiatus period in the months leading up to the Apollo lunar landings. Von Braun had taken the opportunity to visit the Shrine of Apollo in Greece where, as luck would have it, he was recognised by a reporter from *Paris Match*. About the same time, astronaut Frank Borman of Apollo 8 fame was paying his respects to the Pope. Both facts were subsequently pointed out by the Press at their Conference prior to the Apollo 11 launch. Why was it, they wanted to know, that von Braun was paying homage to a Greek God while Frank Borman was seeing the Pope?.

Tom Paine (then NASA Administrator) gave the lightning reply: "We are covering all our bets!"

Apart from his Paris Congress paper, which dealt with the history of Reaction Motors Inc. (Fred worked for them for two years, 1951-3) his current work is a joint volume with Ernst Stuhlinger (also a Fellow of the Society) on the personality of the late Wernher von Braun himself. The book will be partly biographical but will also include some writings, all focusing on how von Braun managed to accomplish such an incredible amount in his lifetime. It should be well worth waiting for.

Besides his main work as a writer, and as a voluntary helper at the Alabama Space and Rocket Center, Fred manages to hold down a full-time job as Director of the Special Projects Office of the US Department of Energy.

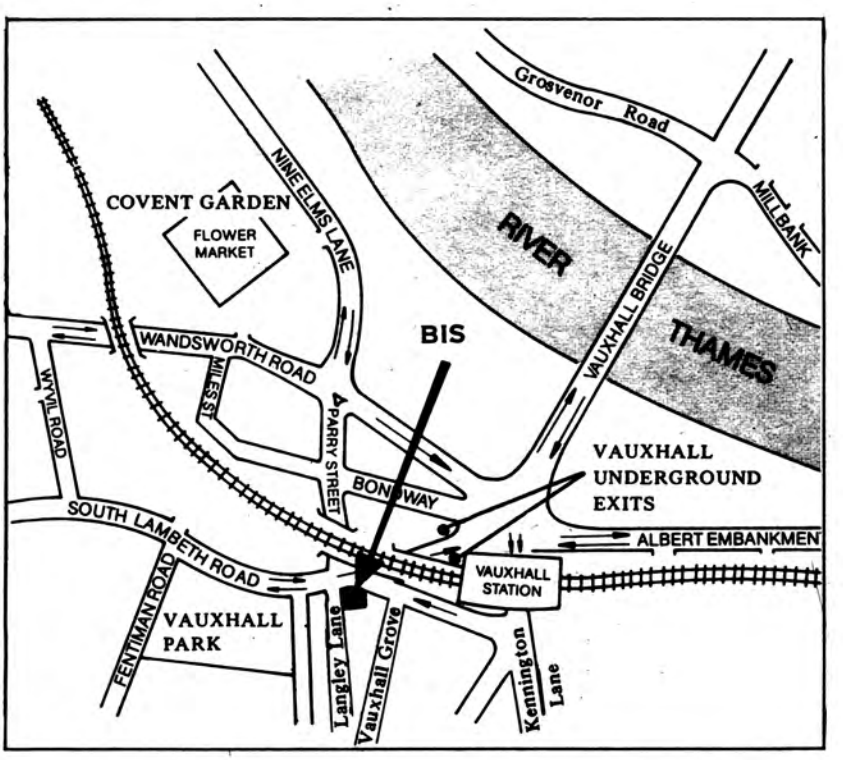
HOW TO FIND US

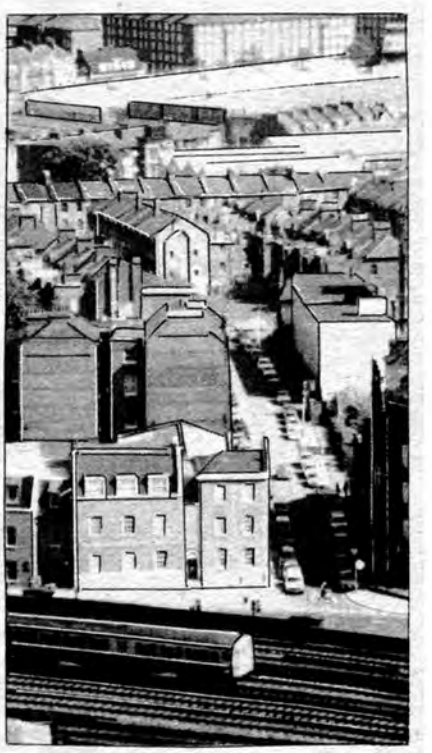
Members, particularly those from overseas who have not been to London before, sometimes need to visit the Society on business or seek an opportunity to look over our new HQ building and meet with some of the staff.

In view of the difficulty which they sometimes find in locating us in an unfamiliar town, we have prepared the adjacent map showing the location of the immediate vicinity of our HQ, which can be seen more visually (bottom centre) in the accompanying photograph by Derek Webber taken from the top of the INMARSAT HQ in Vauxhall just before they moved to new premises.

The landmark is Vauxhall Bridge over the Thames, with our HQ immediately facing the overhead railway bridge which runs parallel to the river on the south side of Vauxhall Bridge.

As will be seen, our HQ also immediately faces Vauxhall Underground Station. This is on the Victoria Line and provides ready access to and from central London.





Space Museum Exhibition

Sir, The Smithsonian Institution's National Air and Space Museum in Washington, D.C. is celebrating the first quarter century of the space age with an exhibit on "25 Years of Space Exploration." It opened on 1 July 1982, the 25th anniversary of the International Geophysical Year (a coordinated study of the Earth and its atmosphere by 67 nations). It was the IGY that provided both the United States and the Soviet Union with the incentive to establish programmes to launch the first satellites.

The exhibit consists of five modules which place the developments of the space age against the background of social, cultural and other events of the time. Five video displays run continuous film segments of the entertainment and news stories of each period, as well as filmed accounts of launches and space events.

The first module, The Beginnings (1957–1958), covers the period of the early satellites; Man in Space (1961–1965) highlights the Mercury flights; Lunar Conquest (1966–1969) describes the "race" to the Moon; Space is Commonplace (1970–1976) begins with the launch of the Jupiter probe Pioneer 10, and covers both Skylab and the Apollo-Soyuz test project; Today and Tomorrow concentrates on the present period of space exploration, with emphasis on Voyager and the Space Shuttle.

Perhaps the most admirable part is the attempt to place space exploration in context. The social, cultural and political background of scientific events is often neglected in science museums. But one cannot look at the history of space exploration without taking into account the American-Soviet rivalry in 1957 (and today), or the seemingly limitless confidence in technology which encouraged the early space programme.

The show's major flaw, perhaps understandably, is that it focuses on American space efforts, to the exclusion of other national and international space activities. When Soviet accomplishments, such as Sputnik, are mentioned, it is often couched in terms of competition. Even in the section on the future, virtually no mention is made of past or present European or Japanese space ventures. The European Space Agency is given a one-sentence credit in the last module. Ironically, while the fourth test flight of the Space Shuttle was in progress when the show opened, so was a joint French-Soviet space mission.

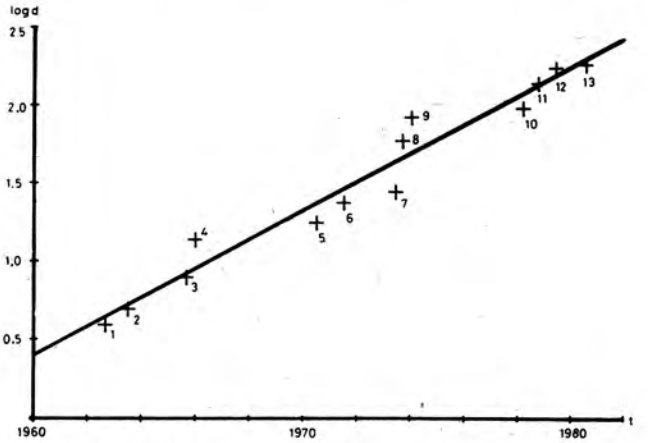
"25 Years of Space Exploration" is really only a starting point; it is accompanied by maps showing where spacecraft mentioned can be found in the museum, and a self-guided tour booklet using the entire museum for an expanded version of the show. The exhibit will be open until February 1983.

THECLA FABIAN
JAMES SWEENEY

The Dangers of Extrapolation

Sir, I happened to re-read the October 1981 issue of *Spaceflight* in which Dr. Almar[1] plotted the durations of record manned space flights against the date of the flight. He found a 0.978 correlation of log (duration) against date, and, by extrapolating, suggested that by 1991 we will have a 5-year flight.

Looking at the extrapolation of his linear function another way, we could investigate the dates at which we might expect 45-year and 74-year flight durations. These would represent stays of a person's working lifetime and of a person's complete lifetime, respectively. The first represents continuous manned orbital operations with people being sent up from Earth after training and returning to Earth on retirement. The second represents that major step forward when people are born, brought up, work, retire and die in space, essentially independent of Earth. Dr. Almar's graph suggests that these two advances will be achieved as early as the years 2001 and 2004, respectively.



The numbers of the diagram refer to:

1. Vostok 3
2. Vostok 5
3. Gemini 5
4. Gemini 7
5. Soyuz 9
6. Soyuz 11 - Salyut 1
7. Skylab 2
8. Skylab 3
9. Skylab 4
10. Soyuz 26/27-Salyut 6 (Romanenko/Grechko)
11. Soyuz 29/31-Salyut 6 (Kovalyonok/Ivanchenko
12. Soyuz 32/34-Salyut 6 (Lyakov/Ryumin)
13. Soyuz 35/37-Salyut 6 (Popov/Ryumin)

Unfortunately, Dr. Almar's graph is based on an inappropriate mathematical model. Firstly, drawing his line back to a zero duration suggests that the first manned flight would have been in late 1955. More subtly, to achieve a 74-year duration in 2004 we would have had to put an O'Neill-type space colony into orbit as long ago as 1930 (2004 minus 74). Even the BIS could not have done that! The linear function begins to fail when the space flight duration record increases at a rate greater than one year per year, ie by about October 1983. Dr. Almar's line should then become asymptotic to log(d)=2.56.

It may be that more detailed analysis of the existing data, eg plotting log(d) against cumulative calendar time since the date of the first manned space flight (ie a Duane plot; see Ref. 2) might already indicate the start of such asymptotic behaviour. Certainly, inspection of the graph suggests learning curve behaviour (eg consider the sequences 1-2-3, 3-4-5, 5-6-7, 7-8-9-10 and 10-11-12-13), with spacecraft-fleet lifetimes of about 4 years, a growth rate of 0.34 and a generation time of about 27 years for the Improvement Factor of 44. Both the growth rate and the generation time seem entirely reasonable by aerospace standards[2], but I would expect the fleet lifetimes to extend as space technology matures.

TIM GRANT
Bushey Heath

REFERENCES

1. *Spaceflight*, **23**, 8, Correspondence.
2. Grant, T. J., "Estimation of Reliability and Maintainability Improvement Rates Using the Duane Model", *JBIS*, **35**, 3, 125–129 (1982).

Soviet Photographs

Sir, Within the past couple of years the Soviet Union has published several interesting pictures showing its spacecraft, many of which have not been published before. Some are described below.

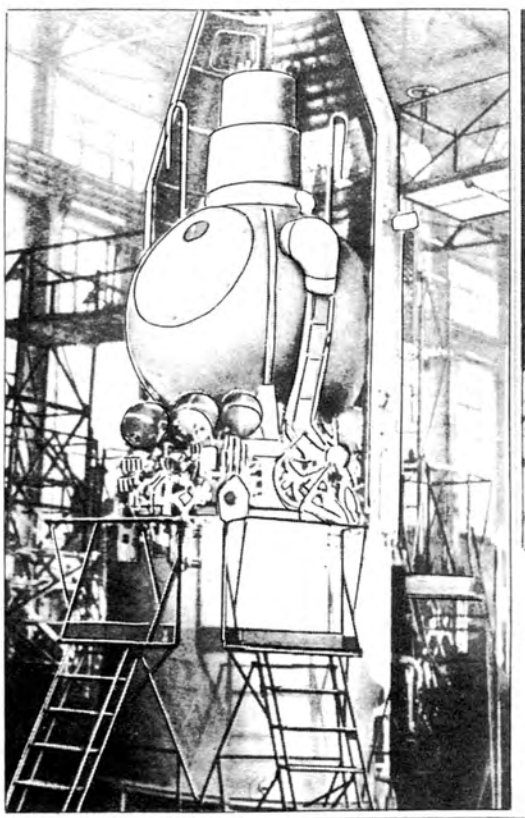
1. VOSKHOD 2. This picture, from the book "Sovietskaya Kosmanavtika", Mashinostroene publishers, 1981, shows the Voskhod 2 spacecraft in the MIK assembly shop before the second half of the payload shroud was attached. The book describes Voskhod as a modification to the basic Vostok spacecraft, a fact that BIS members have been aware of since 1974.

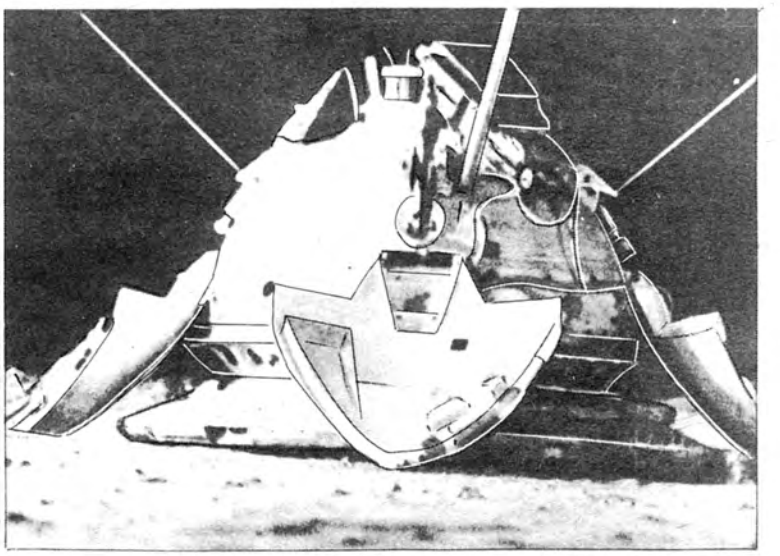
2. MARS 2 LANDING CAPSULE. Again from "Sovietskaya Kosmanavtika", this picture was originally published a couple of years ago in a Soviet youth magazine. The resemblance to the Luna 9 and 13 landing capsules is self evident.

3. SALYUT MODIFICATION. This picture, from the April 1982 "Aviatsiya i Kosmanavtika" shows what I believe to be the Kosmos 1267-type modification to the Salyut space station. This mock-up is in the hydrotank at Star City. Note the sphere on the right hand side of the picture which may be a Soyuz T Orbital Module.

4. SOVIET SHUTTLE. This picture, from the book "Our Gagarin", Progress Publishers, 1978, is quite well known to Soviet spacewatchers. The picture purportedly shows the Vostok cosmonauts examining a mock-up of a Space Shuttle Orbiter (looking remarkably like the NASA/Rockwell Orbiter.) The presence of Gagarin indicates that the photograph is dated before 1968, however it has a distinct "forged" look about it. If the picture is a forgery then the reasons for its use are quite obscure, to me at least!

NEVILLE KIDGER
W. Yorks





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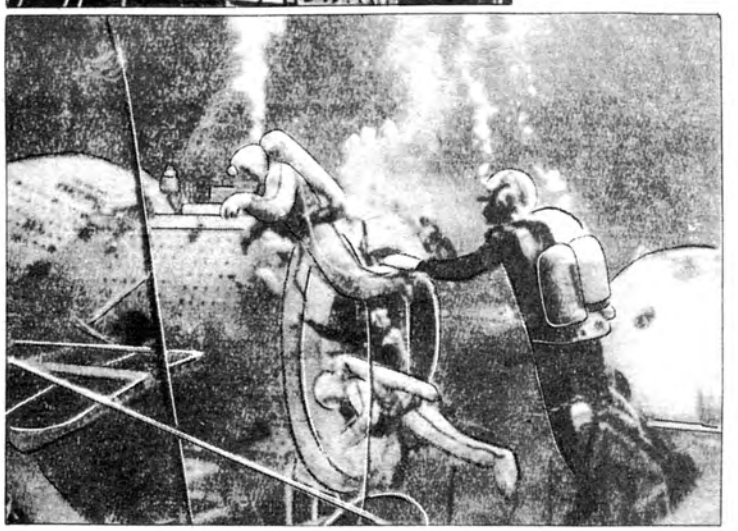

Shuttle Astronauts

Sir, Now that nearly all the active astronauts from the first seven groups have been assigned to a Shuttle flight and with most positions for the STS missions up to STS 9 known, it is now possible to predict possible assignments for flights STS 10–15.

With the announcement of the crews for STS 6-9 a pattern appeared. Crippen and Truly, who flew as Pilots on STS 1 and 2, were assigned to the Commander positions on STS 7 and 8. It is therefore reasonable to assume that other Group 7 men will gain Commander's seats on later STS missions in the following order: Fullerton (STS 3), Hartsfield (STS 4), Overmyer (STS 5) and Bobko (STS 6). Peterson will serve as a Mission Specialist on STS 6 and if he does make a second flight it is probable that he will again fly as Mission Specialist.

With the announcement of John Young to fly as Commander of STS 9, the first Spacelab mission, it again becomes apparent that Pilots from the other remaining active Group, the fifth, will command future important flights, like the early Spacelab missions, the first flight of each new vehicle and historic or difficult missions, such as SMM retrieval, Space Telescope, etc.

If the same procedure applies then the Young, Engle, Lousma, Mattingly, Brand, Weitz order will repeat itself for these important missions. The next after Spacelab 1 is the first flight of Orbiter 103 *Discovery* scheduled for January 1984, Engle should be named for this mission.

Active astronauts from the fourth and sixth groups, the scientist astronauts, will probably be assigned to the early Spacelab missions, and important flights in the STS series.

Gradually, the eighth and ninth groups will figure more and more in the flight schedule and the Pilots, after possibly two flights, will probably be promoted to Commander. By then most, if not all, of the Group 1–7 astronauts will be out of the main stream of flights.

My preliminary suggestions for the initial flights of STS 10–21 mission Commanders are shown below.

10 Fullerton (STS 3)
11 Possibly Hartsfield, with McCandless and England?
12 Engle (STS 2)
13 Overmyer (STS 5)
14 Bobko or Lousma
15 Lousma or Mattingly
16–18 Possibly Crippen, Truly third flights, with Group 8 Pilots on their second missions.
19 & 21 Spacelabs 3 and 2, Brand and Weitz, with Lind and Thornton (SL 3) and Heinize (SL 2).

From the 20th flight we should see the first Group 8 Commanders, with Group 9 as Pilots.

The outcome of these assignments will, of course, be subject to certain crew replacements but it would be interesting to review the assignments at a later date to see if indeed a selection pattern for STS flights does exist.

DAVE SHAYLER
W. Midlands

The crew of STS 10 was announced in October as: Mattingly (Cdr), Loren Shriver (Plt); Ellison Onizuka & James Buchli (Mission Specialits)—Ed.

Defining Astronauts

Sir, In response to Gordon Hooper's reply to my comments on the definition of an astronaut (*Spaceflight*, Sept/Oct 1982, p. 383), we should include all those people who have been in space. Whether they reached space in an aircraft or spacecraft is immaterial. Every flight over 50 miles (80 km) qualifies as a space flight. In other words, the X-15 flights above 50 miles (13 of them) should be taken into account. Of the 12 men who flew the X-15, eight (Adams, Dana, Engle, Knight, McKay, Rushworth, Walker and White) achieved the astronaut rating. The current listing of humans in space *must* be altered.

ANNE VAN DEN BERG
The Netherlands

This correspondence is now closed–Ed.

Space Rescue

Sir, Still in the midst of tests, the Soviet Cospas search-and-rescue beacon on board the Cosmos 1383 spacecraft launched on 29 June 1982, aided in the rescue of three Canadians whose light plane crashed in the northern British Columbia province in early September. After an initial unsuccessful search flight, the Canadian Forces search-and-rescue centre at Trenton, Ontario was notified of the lost 'plane. Officials there then notified Soviet authorites as part of the agreement that provided for compatibility of each nation's Sarsat system. Approximately five hours later the Soviet spacecraft overflew the crash area and picked up the emergency locater beacon signal, resulting in a positional fix that was relayed to the Canadians. The next day the aircraft was discovered within 22 km of the position provided by the satellite. The three men were then airlifted to hospital for medical attention, in the first rescue aided by a satellite in space.

JOEL POWELL
Canada

Local Artefacts

Sir, I have followed with interest recent correspondence in *Spaceflight* about local industries carried on in the area where our new HQ stands.

There is no doubt that it is a very historical area, indeed. Regarding local artefacts, it appears that Stephen Green established a pottery factory nearby about 1820 which continued under his management as the Imperial Pottery until 1858. When he first began, Green was one of only six or seven stoneware potters in Lambeth, all of them making bottles for blacking, ginger beer, cider, sprucebeer, porter and ink. At one time, I believe, there were nearly 20 potteries operating in the immediate vicinity!

Has any member ever seen the products of William Northern's Vauxhall Pottery, for example, operated in Lambeth from 1847–1892? He put out many flasks containing the decoration of Queen Victoria (or an old lady taking snuff!) placed within a central medallion.

The Society certainly ought to possess one of these as a momento of the past, if any are still around.

A. T. LAWTON
President, BIS

We've never heard of any flasks like those described - Ed.

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorteb or otherwise adapt material to fit, for this reason.

BOOK NOTICES

Alternative Space Futures and the Human Condition
Ed. K. Karnik, Pergamon Press, 175 pp, 1982 $20.00.

This volume contains the results of the international round table held in New York in March 1982, one of the activities organised in connection with the second UN Conference on the Exploration and Peaceful Uses of Outer Space. The chapters are an edited version of the discussions, the editing being somewhat drastic but with a positive effort made to retain the flavour of the original remarks.

Space is considered from a number of aspects i.e. the future for Man, how it will effect his condition and education, cooperation between nations and as a future intellectual adventure and source of a new social ethic.

On the educational aspects, most hope lies in the expectation that broadcasting satellites will revolutionise the traditional means not only of spreading education but of upgrading its quality and, eventually, wiping out illiteracy even in the remotest corners of the world. In reality, however, progress in the actual use of such systems has been disappointingly slow, in spite of several very interesting applications.

The book has been prepared from typewritten format. Each heading contains a number of remarks, many *ad lib*, made by participants expressing their individual opinions rather than those of the organisations they represented. Since the volume, essentially, reports discussion, the flow of words is as spoken rather than as written, with the result that many readers may consider that the verbiage is still far too great and that the editing should have been even more drastic.

Space: Mankind's Fourth Environment
Ed. L. G. Napolitano, Pergamon Press, 450 pp, 1982 $90.00.

This, selected proceedings of the 32nd IAF Congress held in Rome in 1981, encompasses a valuable collection of papers on the most recent developments and applications of space technology, promoting an awareness of the problems and challenges involved in the use and management of space and the development of the necessary technology for further exploration.

The proceedings consist of four parts. The first addresses itself to the problems and the challenges presented, the second deals with space exploitation in such areas as communications satellites, the third the exploration of the Solar System and the search for extra-terrestrial intelligence. The last surveys the state of the art on a variety of topics and includes papers on other topics, e.g. astrodynamics and propulsion.

Leadership in Space – For Benefits on Earth
Ed. W. F. Rector, AAS, 310 pp, 1982 Hard cover $45.00, Soft cover $35.00.

This is Volume 47 in the same series as the previous volume. It is based on technical sessions of the AAS annual meeting held in San Diego in 1981 and covers recent developments in space defence applications, communications, transportation, navigation, exploitation, etc.

The theme paper concerns the problem of transferring the discoveries of high technology to the benefits of industry and hence to the market place and to the consumer. It is not easy to quantify this fall-out in specific terms but every indication points to an enormous increase in the productive capacity of the nations involved. For example, the area of space communications now has a solid basis. The same, no doubt, will shortly apply to space-aided navigation. Other similar situations will develop in due course as the advantages of large space platforms materialise and the critical voices of those complaining about the cost e.g. of the necessary launch vehicles, become stilled.

There is very little doubt, however, that a country which undertakes a space programme has to be primarily concerned in advancing new technologies in all areas. The cost of these attracts an unimaginative response from those who equate it with the actual purchase of an item, not realising that the problem is one of advancing the frontiers of knowledge rather than purchasing a ready-made product.

This volume is a feast of comment on the size and nature of the outstanding benefits which have been derived from the space programme. It is probably no exaggeration to say that the benefits received to date, when quantified, exceed even the enormous cumulative costs of the space programme, including all the vast sums spent to acquire initial know-how.

Unlike most volumes, this book does not attempt to justify space programmes in terms of minor spin-off capacities, but in major areas. Even so, as computers have shown, problems lie in determining where spin-off ceases. It probably carries on to the very limits of a country's activities.

Mercury's Perihelion from Le Verrier to Einstein
N. R. Roseveare, Clarendon Press, 280.pp, 1982 £20.00.

The story of the motion of Mercury is one of the most fascinating in the history of astronomy. This tiny planet, hard to see, has the added claim of never being quite where it ought to have been. It was even thought that there might be a planet, yet closer to the Sun, which perturbed its motion. Several reported sightings of this mythical planet were accepted at one time and it was given a name, Vulcan.

When these observations were discounted, more and more astronomers began to try to solve the problem. Many theories were advanced, including one which suggested that matter surrounding the Sun was the cause. Other astronomers examined Newton's law of gravitation to see if some alteration to that law might explain the reason for Mercury's advance in perihelion, but it was only the publication of Einstein's General Theory of Relativity, at the end of 1915, which finally accounted for the differences.

The purpose of this book is to present a detailed history of these, and many other, attempts to solve the problem of Mercury's motion and to place each in its scientific context. Up to recently all these theories were spread among the literature and it is only now, probably for the first time, that one can see a substantial historical account presented in one complete volume.

The book contains much of interest to the general reader but, being so heavily dependent on mathematical concepts, substantial basic knowledge is required to derive the most out of it.

Supernovae: A Survey of Current Research
Eds. M. J. Rees and R. J. Stoneham, D. Reidel, 590 pp, 1982 $69.00.

Theorists are now achieving a consensus on the physical mechanisms which cause some stars to end their lives in supernovae explosions. Recent data in the radio, ultraviolet and X-ray bands have added greatly to current understanding of supernovae, and their remnants, and to the physics of supernovae remnants in relation to the interaction with the interstellar medium and cosmic ray acceleration.

This volume reviews the present state of knowledge of the subject and, by discussing the later stages of stellar evolution, nucleosynthesis etc., place supernovae in a broader context. Relevant observations of supernovae light curves, statistics and pulsars are also dealt with.

Other papers in the book deal with the new techniques employed in discovering supernovae and the relevance of such objects to the general problem of stellar and galactic evolution.

Extragalactic Astronomy
J. L. Sersic, D. Reidel Publishing Co., 245 pp, 1982 $49.56.

A normal galaxy is one composed mainly of stars and whose radiation is almost entirely the sum total of the optical radiation of individual stars. Modern observation, however, has allowed astronomers to detect radiation beyond the optical range, resulting in the discovery of galaxies that emit other types of radiation in amounts comparable with, or even larger than, those expected if they were "normal." Indeed, some galactic nuclei radiate as much in infrared and ultra violet or even in X-rays. Radio galaxies emit much of their energies in radio frequencies, obviously, but in most cases this

emission comes in regions where there are neither stars nor other visible objects. This is why there is a need for classification in some sort of order of the great variety of objects observed in the Universe.

This book attempts to do just that, with text describing the characteristics of many of the objects referred to.

After a first chapter on morphology and ideas on classification of galaxies, the second gives most of the basic information about normal galaxies, as individual objects. Active galaxies are described in chapter III while chapter IV deals with the mutual relationship between galaxies and their environment. The scale of distance is considered in chapter V. Distance indicators are introduced and several conflicting viewpoints of different schools of thought are presented. Chapter VI deals with cosmology, just to give the necessary elements for chapter VII, where gravitational instability and galaxy formation are discussed. Chapter VIII is an appendix containing additional notes.

Compendium in Astronomy
E. G. Mariolopoules *et al* (eds.), D. Reidel Publishing Co., 464 pp, 1982, $49.50.

This is a volume of 36 essays dedicated to Professor Xanthakis on the occasion of completing 25 years as Fellow of the National Academy of Athens.

The book contains a variety of papers which cover a wide range of fields in astronomy, astrophysics and space research. Topics dealt with include the recent exploration of Mars and Jupiter by space probes, the physics of black holes, extraterrestrial intelligence, optical systems for spacecraft, the theory of orbits, planetary and stellar systems, solar activity studies, various types of stars, the Magellanic Clouds and other galaxies, etc.

Over 30 leading scientists in relevant fields have contributed to the text.

Compendium of Communication and Broadcast Satellites 1958 to 1980
Ed. M. P. Brown, Jr., Institute of Electrical and Electronics Engineers, NJ, USA, 375 pp, 1981, $34.95.

This is an extremely useful Compendium of Communication and Broadcast Satellites which sets out essential information, in uniform style, for nearly 50 different satellite *types*. Since there are often many spacecraft for each family, the total number encompassed is, at least, several hundred. For each type, the data presented consists of:

(a) A full page satellite picture.

(b) A block diagram of the communication payload.

(c) A frequency plan showing the communication and broadcast bands utilised.

(d) A listing of major transmission parameters, physical characteristics and other general information.

(e) The date of introduction into service and the designed lifetime.

After a short introduction, one gets straight into the classified data, with the satellites themselves under various headings which indicate the purposes they are designed to serve, e.g. International, Regional, Domestic, Military, Experimental, etc. The volume ends with a range of references, grouped together in the same order in which the main data appears so that the references for each particular section can be easily identified.

All this information is presented in a very clear form and provides a reliable and readily accessible summary of available data.

Giant Molecular Clouds in the Galaxy
Eds. P. M. Solomon and M. G. Edmunds, Pergamon Press, 344 pp, 1982 £23.00.

The mapping at mm wavelengths of the spectral emissions from molecules in the Galactic disc has led to the discovery of an important new and very significant feature of the interstellar medium, namely, Giant Molecular Clouds. These are a major component of the Galaxy in terms of mass and must have had a fundamental influence of Galactic evolution, particularly as it appears that associated with them is most, perhaps all, of the massive star formation occurring at the present time.

The discovery of GMC's stemmed from mm line studies of the sky around HII regions and infrared sources and nearby dark clouds, but it was only with the advent of large survey programmes that their number and extent became apparent. The discovery of a galactic ring of molecular clouds between 4 and 8 kpc from the Galactic centre demonstrated the widespread occurrence of molecular clouds in the Galactic disc.

During the past three years a tremedous expansion in observational studies of molecular clouds of all types has taken place, leading to some interesting theoretical work on the relationship of such clouds to star formation. The symposium, the proceedings of which appear in this volume, was called to bring together in one place this wealth of new data and ideas. There was a particular orientation towards understanding the most massive of the interstellar clouds and their role in star formation, but other interesting work on the smaller clouds, and cloud chemistry, was also presented.

As with any new concept, many questions suggest themselves. For example, what maintains these clouds against rapid collapse, and why is the star formation within so inefficient? How do such giant complexes form and what is the level of chemical structure reached by molecular reactions deep within the clouds? When will we see future extension of these studies at high resolutions to nearby galaxies.This is a tantilising prospect. Do the Magellanic Clouds have similar formations?

This volume will do much to help stimulate interest is some of the most important objects in the night sky.

A Photometric Atlas of the Orion Nebula
A. D. Andrews, Armagh Observatory, 100 pp with charts and transparent overlays, 1981, £25.00.

The 1970's provided the optical astronomer with an unrivalled opportunity to investigate photometric data in a manner previously impossible. One such example, the present atlas, represents the author's second work in cataloguing stars in the Orion nebula region based upon a red plate, in this case ESO 3132 taken on 27 January 1979 by the Schmidt Telescope at the European Southern Observatory.

The richness of the Orion nebula region, one of the nearest prime targets for current optical, infrared, X-ray and gamma ray investigations into young galactic objects, stars at birth, and their parent gas and dust clouds, deserves such a volume.

The volume consists of 32 pages of text, 12 pages concerned with the atlas itself and its transparent overlays, plus a further 56 pages which catalogue the objects shown.

The atlas itself contains the equatorial co-ordinates (1950) for some 16,000 stars of visual magnitude brighter than 16 in the outer region (21° square) of the Orion Nebula. The maps are printed in six sections, all of which are shown in a master chart. A total of 666 objects are also indicated.

Planetary and Lunar Coordinates for the Years 1980-1984
HMSO, 84 pp, 1979 £1.75.

This work continues three previous volumes which covered the period 1800-1980 but differs from them mainly because of its considerably wider scope i.e. the present volume contains geocentric as well as heliocentric coordinates, and lunar as well as planetary coordinates. These changes are intended to extend its usefulness, more particularly when applied to computation of the orbits of comets and minor planets.

The volume is primarily intended to provide low-precision astronomical data in advance of the annual publication of *The Astronomical Ephemeris.*

A further volume in this series is planned, probably covering the years 1984-1990.

Some of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Photoelectric Photometry of Variable Stars
D. S. Hall and R. M. Genet, IAPPP, 280 pp, 1982 $22.50.

Until fairly recently observations of variable stars were made largely by amateurs applying mainly visual estimates since few could afford a spectrograph or a telescope of the size needed to use such an instrument effectively. This in no way limited the value of their observations since most professional astronomers, also, worked on either visual or photographic estimates.

The situation changed dramatically with the introduction of the multiplier photocell developed during World War II, coupled with increased reliability of electrical components generally. The multiplier photocell made it possible for work with, e.g. a 12 inch telescope to reach limits previously available only with one of 60 inches or larger.

The book provides, in convenient form, most of the information needed by small observatories to equip themselves for and to conduct photoelectric observations of variable stars. Thus, the emphasis is on practical considerations and includes substantial information on the equipment required, suitable observing programmes, data reduction, etc.

The book, prepared directly from an original typewritten format, is very much concerned with imparting technical information on the electronics involved, though it also includes several introductory chapters, e.g. there is one on the Earth's atmosphere to help set the scene. Observation programmes, for example, include references to long-period and short-period variables, discovering new variables, etc.

The book can be obtained direct from the authors at Fairborn Observatory, 1247 Folk Road, Fairborn, Ohio 45324, USA.

Webb Society Deep-Sky Observer's Handbook Vol. 5, Clusters of Galaxies
Ed. K. G. Jones, Lutterworth Press, 241 pp, 1982 £8.50.

This is one of a series of independent volumes addressed to the more serious amateur astronomer to commemorate the famous work by Rev. T. W. Webb called *Celestial Objects for Common Telescopes* published in 1859.

Galaxies not only exist in clusters but these, in turn, are organised into superclusters, the grandest and most accessible being the Coma-Virgo group which provides a rich field of exploration with modest telescopes, though the fainter and more distant clusters are observable only with powerful instruments.

It is unfortunate that galactic clusters are such disappointing visual telescopic objects. Only large-aperture systems reveal even the nearest and most conspicuous clusters as interesting objects to the novice. Few professional telescopes even produce pleasing photographs of clusters for they are, basically, widely scattered objects of very low brightness, yet they probably contain the clues to the basic structure of the Universe and present some of the most exciting problems at the forefront of modern astrophysical research.

This volume provides a general introduction which sets out the theoretical background, techniques, finding-charts and field drawings necessary for observing clusters, followed by a catalogue which gives guidance in making visual observations of 80 galaxies, including drawings which show the telescopic appearances of many. This catalogue section covers 15 "rich" clusters (containing 175 galaxies) and 13 "poor" clusters (containing 120 galaxies).

The Nature of Symbiotic Stars
Ed. M. Friedjung and R. Viotti, D. Reidel, 310 pp, 1982 $43. 50.

Symbiotic stars have long puzzled astronomers. While most students of the subject have considered them to be binary stars, many have, at different times, supported single star models. The nature of their outbursts is uncertain and the dividing line between symbiotic stars and novae is unclear. Doubts are raised even as to whether a class of symbiotic stars really exist at all. This, therefore, is a very timely book, covering as it does the proceedings of the first international conference devoted exclusively to a limited field that has been the source of many heated debates. It deals with recent results which are having profound effects on the development of the subject, and discusses observations in all spectral regions. This is followed by a detailed consideration of specific stars, taking into account that they differ markedly from each other and it is not clear whether they all have the same physics. Their classification and the interpretation of the observations in binary and other model frameworks are then considered, leaving to the end an examination of the significance of these stars within the pattern of stellar observation.

Instrumentation for Astronomy with Large Optical Telescopes
Ed. C. M. Humphries, D. Reidel Publishing Company, 322 pp, 1982 $48.50.

At a time when recent advances have produced a dramatic increase in the detection efficiency of astronomical instrumentation, for example, with the advent of charge coupled detectors and single photon counting systems, it is appropriate to review the progress made in this area. This new volume, which contains the proceedings of IAU Colloquium No. 67 held in Zelenchukskaya, USSR, deals with the topics of spatial and spectral interferometry, conventional and new designs for spectrographs, image intensifiers and solid state detectors, together with a discussion of large telescopes and the efficient matching of telescope images and instrumentation. The spectral region considered includes infrared as well as the visible regions.

Automated Data Retrieval in Astronomy
Eds. G. Jaschek and W. Heintz, D. Reidel Publishing Company, 326 pp, 1982 $48.00.

Part of the scientific community still maintains a traditional attitude towards new information storage and retrieval systems. Shelves of printed books and catalogues are regarded as irreplaceable with doubts held as to the quality and completeness of material provided *via* terminals.

This is a timely volume, therefore, dealing as it does with the proceedings of the 64th Colloquium of the IAU which was organised to cover most aspects of work with machine readable data.

Among other topics, the book deals with existing data centres, data networks, new hardware, recent software developments, data in astronomy, and data in space astronomy.

Guidance and Control 1982
Eds. R. D. Culp, W. J. Baughman and W. E. Dorer, AAS, 558 pp, 1982 Hard cover $65.00, Soft cover $50.00.

This is volume 48 in the series of volumes entitled Advances in the Astronautical Sciences, issued by the AAS. It is based on an annual conference on guidance and control, the proceedings of earlier conferences having appeared in other volumes in this series.

The present volume covers Earth orbiting control systems, historical guidance and control hardware (storyboard displays), making software work, the next generation, and flight experiences and lessons learned. A total of 30 papers are included. The variety of matters dealt with is extensive, ranging from Earth orbiting objects, including the Shuttle and the particular problems of the high accuracy demanded of the Space Telescope, to the Viking and Voyager probes.

Printing has been made direct from the author's typewritten originals. This causes some variation in style but the general results are clear with the quality of illustrations maintained at an acceptable level.

High-Precision Earth Rotation and Earth-Moon Dynamics
Ed. O. Calame, D. Reidel Publishing Co., 354 pp, 1982 $54.50.

The dynamics of the Earth-Moon system, in which there are strong interactions between orbital, rotational and deformational motions, has provided many clues to our understanding of Solar System physics and astronomy. The rotation of the Earth represents, in this context, a major interface between Astronomy and Geophysics.

This book presents the latest results in theory and observation of Earth-Moon dynamics; geophysical and selenophysical interactions *via* gravity fields, tidal influences, internal dissipation, etc. It also deals with relativistic effects and observational determination of Earth rotation parameters by lunar ranging and other high-precision techniques, including classical astrometry, radio-interferometry and artificial satellite tracking.

Planetary Science: A Lunar Perspective
S. R. Taylor, Lunar & Planetary Institute, 481pp, 1982, $49+p&p.

The nine sets of Lunar samples obtained during the Apollo and Luna missions have contributed to a massive outpouring of scientific literature, conservatively estimated at 18,000 articles in the last decade alone.

The aim of this volume is to synthesise much of this material and to provide a concise account as to how it has led to a greater understanding on the origin and evolution of the Universe.

The author, himself a member of the Lunar sample preliminary examination team for Apollos 11 and 12, carried out some of the first chemical analyses of Lunar soil ever undertaken.

His current volume concentrates on studies of the Moon but also includes substantial references to the non-gaseous planets and satellites, thus providing a ready means of comparison.

Particular attention is given to the surface features of the Moon i.e. the craters, multi-ring basins and structure generally, as well as to consideration of the underlying lava flows and past movements which have led to the formation of the present interior. The volume ends by considering early conditions which might have led to the evolution of the Moon and planets as we know them today.

This is a concise and highly-readable book which really does a good job in placing much of our current knowledge of the Moon into perspective. One cannot help, however, but reach the inescapable conclusion that the time is fast approaching now when the need for further detailed surface examination of the Moon, Mercury and Mars, for example, will become imperative.

Communications Satellite Systems: An Overview of the Technology
Eds. R. G. Gould and Y. F. Lum, John Wiley, 164pp, 1976, £14.85.

This volume has been published on behalf of the Satellite Systems Panel of the IEEE Aerospace and Electronics Systems Society. Since their original venture appeared in 1972 with the title of "Review of Satellite Systems Technology", the communications satellite field has expanded in all directions, hence what is really an updated version of the original book with a change in title.

The aim is to provide a ready reference to communications satellite systems both easily accessible and readily understood by scientists and engineers not themselves specialists in the subject.

The present volume contains five main sections plus an Addendum. Part 1 discusses communications satellite systems used or planned, Part 2 the techniques for optimizing or expanding system capabilities and Part 3 problems and practices in management and utilization.

Part 4 is concerned with Earth-station technology, a rapidly expanding segment of the space industry of great interest to industry at the present time. Part 5 highlights some of the interface problems.

The book is best used with its companion volume entitled "Literature Survey of Communication Satellite Systems and Technology' by J. H. W. Unger.

The Cambridge Photographic Atlas of the Planets
Eds. G. A. Briggs and F. W. Taylor, Cambridge Univ. Press, 255 pp, 1982, £12.50.

This photographic atlas of our planetary system contains many official maps of the planets and their natural satellites, as well as over 200 photographs, more than half of which are in colour. To complement the maps, a careful selection has been made from hundreds of thousands of archival pictures held by NASA to find the best specimens to illustrate particular features. Many of these pictures have not previously appeared in book format.

An introductory chapter sets the scene by describing some current ideas about how the Solar System evolved and the various processes which may have modified the interior surfaces and atmospheres of the Planets over geological epochs. The following chapters then consider each of the planets in turn, summarising our knowledge to date and explaining, in non-technical language, many of the interesting features which appear in the photographs accompanying the text. These chapters are set out with the text in a solid block first all. This is followed by the figures, each of which is accompanied by a longish caption describing its most important features. This approach allows the reader either to use the text for a detailed account of each planet or to browse through the figures and captions instead. In every case, where possible, up-to-date maps of the particular planet or satellite are appended, most of which were produced by the Astrogeology Branch of the US Geological Survey.

The Physical Universe – An Introduction to Astronomy
F. H. Shu, Oxford University Press, 584pp, 1982, £14.95.

This is a sizeable compendium of factual information suitable for a full-year course on astronomy. The text grew from a set of lecture notes prepared by the author and gradually accumulated and refined over his teaching years in America. This explains why, far from being a book for the lowest common denominator of reader, it is likely to challenge the minds of even the best under-graduate students.

Astronomy also offers a cultural value for many non-professional astronomers. The author has not been unaware of their needs and, to that extent, has included a good deal of descriptive material though he carefully pointed out that such readers may well decide to skip the questions at the end of each chapter.

To a large extent, also, this volume can be used as a "self-educator" book, provided one is prepared to dedicate oneself to the text and supplement it with additional reading where necessary.

Basically, the book consists of four parts i.e. basic principles, the stars, galaxies and cosmology, and the Solar System and life. There is very little in current astronomical studies which is not referred to here though the object is not necessarily to provide the latest news but more to equip the reader with "tools" which will enable him to derive much more satisfaction from his astronomical reading than he might have done in the past.

Landolt-Bornstein, Group 6, Vol. 2 Astronomy & Astrophysics
Eds. K. Schaifers & H. H. Voight, Springer-Verlag, 456pp, 1982, $350.

This exhaustive compilation of numerical data and functional relationships in science and technology has now been extended by a sub-volume relating wholly to data on stars and star clusters.

This sub-volume is the second part, 2b of vol. 6 on the theme of astronomy and astrophysics, the first part of which (6/2a) was published recently, with a third part (6/2c) to be published shortly.

The three main areas dealt with in this new sub-volume are stars generally, special types of stars, and double stars and star clusters. The former includes physical parameters of stars, their magnitudes, colours, atmospheres and structure and evolution. The section on special types of stars includes variable stars, peculiar stars, protostars, planetary nebulae and white dwarfs. The final section is concerned with double stars, star clusters and matters associated with them.

The text follows earlier practice. After concise introductions, really more in the nature of definitions, it makes extensive use of tabulated data, followed by exhaustive references. The amount of data thus assembled is enormous.

The references are particularly informative, though probably not always easily accessible to an amateur observer e.g. the very first section concerned with special classifications, lists both general spectral catalogues and catalogues of special types of stars. The resources of quite a large library would be needed to encompass the material indicated.

Volumes of this type are generally handled in two ways, i.e. they may be referred to very occasionally for abstruse points, or handled so frequently that the layout and contents become familiar. This book should certainly be handled frequently. It has an enormous amount to offer.

Atlas of the Solar System
D. A. Hardy, World Work Ltd., 96pp, 1982, £12.50.

David Hardy has been painting and illustrating astronomy and science subjects since 1954 so, as might be expected from a large-format volume of this nature, it contains some of his very best work.

His current volume has been designed to attract and stimulate the lay reader to all the exciting astronomical developments going on around us. The text is easy to read yet adequate, though the reader's attention will undoubtedly be held by the large number of colour drawings, supplemented in part by photographs but sustaining, largely, the visual representations of the artist.

David provides several references to the Society in his text and also includes our address in the list of bodies to which readers are directed for additional information.

1983 SUBSCRIPTION FEES

Direct Debit Scheme

As from 1 January 1983, our old Bankers Order System is being superseded by the Direct Debit Scheme. Introducing the new scheme smoothly makes it essential that all members who formerly paid by Bankers Order complete and submit their Direct Debit slip at once. Those members who have not already done so are *urged to deal with this without delay*. Duplicate Direct Debit slips are available from the Executive Secretary on request.

Amounts payable for the calendar year January-December 1983 are as follows:

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The additional subscription payable for *JBIS*, where required in addition to *Spaceflight*, is £20.00 ($44.00). For *Space Education*, it is £4.00 ($9.00).

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(d) Remittances from Europe can be made by GIRO: this is the easiest and cheapest method of transferring funds. Our GIRO account number is 53 330 4008.

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(d) Most Canadian banks have UK branches or agents: remittances may easily be made in sterling drawn on those agents. If payment is made in Canadian dollars the current exchange rate may be used, plus the addition of 8 Canadian dollars to cover exchange and collection charges.

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EVERY MEMBER of the Society living in the UK and who pays income tax can help the Society to reach its £30,000 Word-Processor Appeal target, *at no cost*, by completing a Deed of Covenant.

No member has to pay more than his normal subscription: the Deed allows the Society to recover *the income tax you have already paid*. If more members completed Deeds, the total recovered would be substantial.

The response from members in 1982, for example, brought in £1,677 in tax recovered from the Inland Revenue for our Appeal Account, where it was used to offset the bank overdraft and Local Authority loan advanced to pay for the balance of our building.

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Please ask our Executive Secretary for a Deed of Covenant form and complete it without delay. *It will be a great help.*

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

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ASTRONOMICAL STUDY COURSE

During its 50th Anniversary Year, the Society is embarking on its most ambitious Study Course yet. Called "Update your Astronomy", the Course, organised in collaboration with Astronomers at the Royal Greenwich Observatory, provides an opportunity for members to learn of the many new and exciting developments in astronomy in recent years.

The fee for the lectures of the second session is £6.00. Registration forms are available from the Executive Secretary.

Meetings currently scheduled for 1983 are as follows:

5 Jan 1983	"Astronomical Computing"
2 Feb 1983	"The Interstellar Medium"
2 Mar 1983	"Update Your Astronomy" (Film Show)
30 Mar 1983	"Cataclysmic Variables"
6 Apr 1983	"The New La Palma Observatory"
14 Apr 1983	Visit to Royal Greenwich Observatory

Film Show

Theme: **STEPS TO THE MOON – 4**

The fourth meeting in this series will be screened at a meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **8 December 1982,** 7.00-8.30 p.m.

The programme will include the following:

(a) Apollo 16 — Nothing So Hidden
(b) Apollo 17 — On the Shoulders of Giants
(c) The World Was There
(d) The Time of the Apollo

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Study Course

Title: **UPDATING QUASARS**
by Dr. K. Hartley
Royal Greenwich Observatory

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **5 January 1983,** 7.00-9.00 p.m.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of these Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

Lecture

Title: **SPACE COMMUNICATIONS PROGRAMMES IN EUROPE**
by Dr. R. Collette
ESTEC

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **26 January 1983,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Study Course

Title: **THE INTERSTELLAR MEDIUM**
by Dr. M. Pettini
Royal Greenwich Observatory

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **2 February 1983,** 7.00-9.00 p.m.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of these Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

Lecture:

Title: **SPACE LAW TODAY**
by C. E. S. Horsford

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **16 February 1983,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Study Course

Theme: **UPDATE YOUR ASTRONOMY**

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **2 March 1983,** 7.00-8.30 p.m., with a showing of films on the above topic.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of these Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

Lecture

Title: **SPACE OCEANOGRAPHY**
by Dr. J. O. Thomas
Imperial College, London

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **16 March 1983,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

LIBRARY

The Library will be open to members from 5.30-7.00 p.m. on each of the following dates:

8 Dec. 1982	5 Jan. 1983
26 Jan. 1983	2 Feb. 1983
16 Feb. 1983	2 Mar. 1983
16 Mar. 1983	30 Mar. 1983
6 Apr. 1983	

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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SPACEFLIGHT

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VOLUME 25 No. 2

1983 SUBSCRIPTION FEES

Direct Debit Scheme

As from 1 January 1983, our old Bankers Order System is being superseded by the Direct Debit Scheme. Introducing the new scheme smoothly makes it essential that all members who formerly paid by Bankers Order complete and submit their Direct Debit slip at once. Those members who have not already done so are *urged to deal with this without delay*. Duplicate Direct Debit slips are available from the Executive Secretary on request.

Amounts payable for the calendar year January-December 1983 are as follows:

RATES

Members	Sterling	US Dollars
Under the age of 18 years	£16.00	$35.00
Between 18 and 20	£18.00	$40.00
21 years of age and over	£21.00	$45.00
Associate Fellows	£23.00	$50.00
Fellows	£23.00	$50.00

Age Allowance

A deduction of £2.00 ($5.00) is allowed to members of every grade who are over the age of 65 years on 1 January 1983.

JBIS and *Space Education*

The additional subscription payable for *JBIS*, where required in addition to *Spaceflight*, is £20.00 ($44.00). For *Space Education*, it is £4.00 ($9.00).

Methods of Payment

Europe

(a) Payment should normally be made in sterling with a cheque which shows a UK address, either of the paying Bank or its Agent, where it can be presented for payment.

(b) Cheques drawn in sterling on banks in Europe (including Euro-cheques) must include £2.00 to defray bank charges and collection costs.

(c) Banks which remit directly to the Society must be instructed by members to see that the sum is transmitted *free of deductions*. (Banks frequently impose charges "in transit," so the amount actually received by the Society is insufficient to pay for the subscription thus causing much additional correspondence and trouble both to the members concerned and to the Society).

(d) Remittances from Europe can be made by GIRO: this is the easiest and cheapest method of transferring funds. Our GIRO account number is 53 330 4008.

USA and Canada

(a) Payments by US dollar cheques will be accepted if drawn on a Bank which gives an address in the United States or in the UK. US dollar cheques drawn elsewhere need to be increased by $8.00 to cover bank and collection charges.

(b) US dollar notes are accepted. Other currencies may also be accepted with prior agreement by the Society. Their value must be sufficient to include conversion costs into sterling.

(c) US or Canadian money orders can only be accepted *if expressed in Sterling*. *Internal* money orders from these countries i.e. those expressed payable in dollars will be returned as they are not cashable in the UK.

(d) Most Canadian banks have UK branches or agents: remittances may easily be made in sterling drawn on those agents. If payment is made in Canadian dollars the current exchange rate may be used, plus the addition of 8 Canadian dollars to cover exchange and collection charges.

OUT NOW – A NEW SOCIETY BOOK

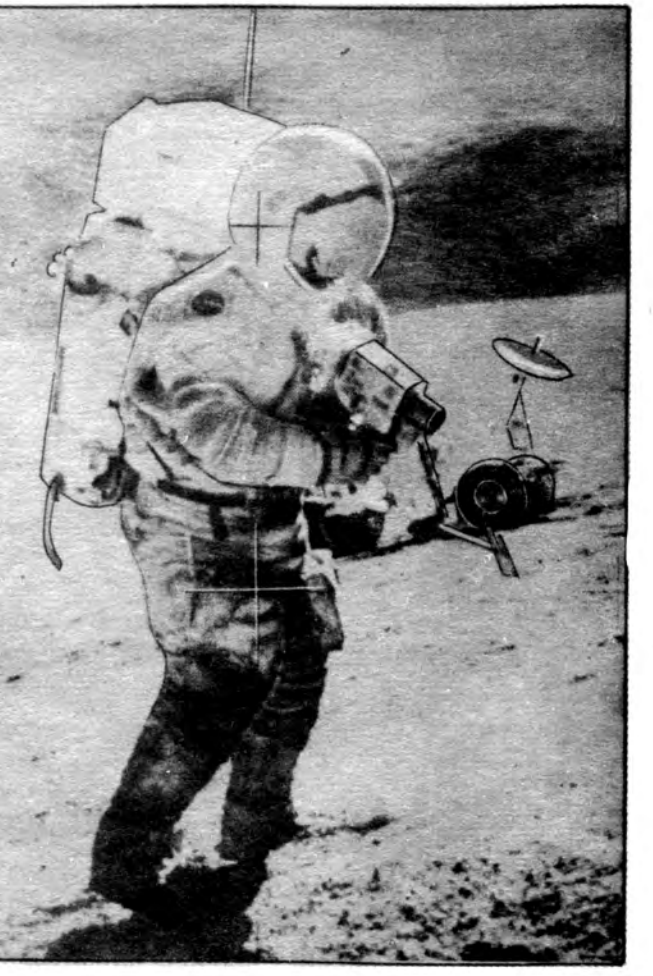
THE EAGLE HAS WINGS

Following the success of the *Daedalus* final report and *High Road to the Moon*, the Society is now publishing a third book.

An exciting progression of space achievements in the years following the Second World War led to Man's first landing on the Moon in 1969. Rockets for probing the upper atmosphere evolved into the space launchers we know today. Vanguard, Explorer, Atlas, Titan, Mercury, Gemini, Apollo – a succession of names to conjure up memories of the 50's and 60's when man was taking his first tentative steps into outer space.

"The Eagle Has Wings" tells the story of the major US Space projects from 1945 to the watershed year of 1975, when the Apollo missions came to an end and the first wave of interplanetary exploration gave way to the more sophisticated probes of today. Written by *Spaceflight* managing editor Andrew Wilson, it is packed with information and photographs. It runs to no less than 144 large-format pages and can be obtained for the low price of £7 ($16.00) post free.

The book is available now. Be sure of your copy by sending for it now, to the British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.



SPACEFLIGHT

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Assistant Editor:
L. J. Carter

CONTENTS

54 Spreading the Word

55 Society News

58 Correspondence

59 Milestones

60 Orbital Transfer Vehicles

61 Training Below for Work Above
John Bird

64 Satellites to the Rescue

65 The Large Format Camera

68 Pioneer Close Encounter

69 Space Communications

70 Space Report

75 Twenty Years On

76 Space at JPL
Dr. W. I. McLaughlin

79 Rescue from Orbit
Gerald L. Borrowman

80 The NASA Geodynamics Program
Clive Simpson

82 Photography of Orbiting Satellites
Joel W. Powell

84 Satellite Digest – 161
Robert D. Christy

85 Astronomical News
Prof. John Griffiths

88 Book Notices

A NEW-LOOK MAGAZINE

This month sees the first of a number of moves by the Society to present *Spaceflight* as a more readable, pleasing-to-the-eye magazine. Initially, our text will be changed gradually over to a larger typeface and the running order of some of our standard features altered to bring them more to the fore. For example, "Society News" and some "Correspondence" will be found towards the front of each issue. After all, this *is* a Society magazine so news and views affecting members should receive proper prominence.

The "Milestones" feature, for many years the occupant of this very space, has migrated into the body of the magazine. Its place will be taken over by a short text on current space matters every month.

Some of these changes will take several months to introduce and we hope that you will bear with us during this period of transition.

SPREADING THE WORD

The Word's Out

The gentle art of "spreading the word" about the Society has developed yet further over the past months, with help from our members, of course! *Environment and Transport World* is the PSA (Property Services Agency, Dept. of Environment) newspaper. The back page of the April 1982 issue had a prominent article about Chris Viles, a BIS member. It describes his involvement, as part of the Museum and Galleries Groups of the PSA, in the erection of the Indian satellite launcher outside the Science Museum during the "Science in India" exhibition there. Chris's membership of, and interest in, the Society was mentioned twice in the short write-up.

In Print

The Society has made it (retrospectively) into the world of fiction, too. Keith Wilson has written to tell of a book, "Vengeance 10" by Joe Power (Michael Joseph 1980). It is the tale of a manned German Moon rocket launched in 1945 from Peenemünde. In one snippet of conversation a German scientist tells his English counterpart that he had "heard that the BIS had fallen on hard times". If that sounds like the past is catching up with us, what about the schoolteacher from Manchester who wrote requesting information? She had found a mention of *Spaceflight* on the old Brooke Bond tea cards series "The Race into Space", which goes back quite a time! Oh, that old publicity continued to bear fruit for such a long time!

The *Oscada County News*, an American local paper, has a columnist who is also a Fellow of the Society, William J. Sauber. He has been responsible for getting the BIS two mentions in the paper. On 20 May 1982 his column praised the Society for publishing an appreciation of Argentinian pioneer Teofilo M. Tabanera at the height of the Falkland conflict. He argues that the common thread of vision binding the proponents of the exploration of space can be a powerful force for peace. On 17 June they also published a letter from Len Carter to the paper concerning the original article.

Books

Elsewhere in publishing, Tim Furniss did the Society proud once more with his latest book "The Story of the Space Shuttle". His Associate Fellowship is mentioned on the cover, but more importantly the inside back flap of the dust jacket includes the Society's address and an exhortation to those interested, and who are not already members, to join. Tim tells us, too, that he suggests the same to anyone who writes to him in response to his regular spot on the Tony Blackburn radio show. The Society is also mentioned several times in the latest book (in German) of long-standing member, Harry Ruppe. His book's title translates as "Spaceflight: The Unlimited Dimension."

Radio and TV

Other types of media mentioned the Society, too. Andy Wilson, Managing Editor of *Spaceflight*, has appeared on the radio several times. His contribution on BBC World Service (broadcast 4 October) and Capital Radio (also 4 October) were about "25 years of Spaceflight". The Capital appearance included a space phone-in. No little green men applied. A third appearance was on the British Forces Network where he talked about the Society's involvement in space, and specifically Project Daedalus.

On television, the Society's Project Daedalus was given a prominent mention in "The Final Frontier", a series of programmes on the near future made for the young by Granada TV and shown on the ITV network.

LJC's Voice Gets About a Bit

Len Carter, the Executive Secretary, has not been idle, media-wise, either. He provided a recording for the Central Office of Information – for world-wide distribution – heralding the opening of Space '82 and describing the Society's objectives. But his electronic persona travelled farther yet than that – in fact, bounced off OTS, no less. He was able to try out a new video link *via* the satellite from Farnborough during the September Air Show. He was on for several minutes and as a result has taken to wearing dark glasses while he is out so he will not be recognised!

Exhibitions

The fact that the Society has been busy preparing for Space '82 has not prevented it helping out with material for other exhibitions. It gains a lot of valuable "exposure" by so doing. On one occasion in September it was material for M. C. Stinton, a member, to use at an exhibition on Space Science and Astronomy for schoolchildren on the Isle of Wight.

Praise Indeed

A sure sign of the perceived professionalism of a Society such as ours is when those accepted to be experts in its field turn to it for advice, help or collaboration. Two compliments of note of that sort have been paid the Society of late. The first was when the Honorary Secretary of AMSAT-UK asked if they could use copies of the article about them in *Space Education* as an explanatory introduction to their work for new members and schools. Another was when "Space News Roundup", newspaper of the Johnson Space Center, asked if the Society Chairman or Secretary would agree to answer a questionnaire on space activities so that they could present the views of a respected body outside the mainstream of the US space effort to their readers. Previous contributors had been Walter Cronkite and James Michener.

A Thank You

This cornucopia of recent Society publicity would not be complete without a mention of, and thanks to, Joel Powell. He recently made up a set of 22 slides, featuring mainly Daedalus and with handsome credits to the Society, for use at meetings. He kindly donated a set to us. Such an example of initiative and enterprise can only be applauded, and we thank him heartily for his gift which the Society will be able to put to good use.

Please Note: Back issues of Spaceflight *can be obtained by members free of charge for promotional purposes at exhibitions, displays, meetings of organisations with space interests, etc.*

SOCIETY NEWS

THE LIBRARY STRIDES AHEAD

With an extremely long shopping list and no pennies to buy anything, acute frustration is the daily hazard of the Library Committee as they drive to make our specialised Space Library evermore comprehensive. On occasions they have not been far short of getting down on bended knees and wringing their hands in the most heart-rending fashion, provided it brought the right response.

The fact that it has done so is more than borne out by a comparison of our stock position which now read as follows:

	25.11.82	9.3.82
Books	2,107	1,993
Reports	4,109	3,932
	6,216	5,925

Seeking members or friends with substantial space or astronomy Libraries, personal papers or instruments and slides, and willing to donate them to the Society continued apace. It was like finding a needle in a haystack, but not without success. Douglas Arnold provided quite a large collection on Remote Sensing, assuaging his conscience with the remark that he hadn't found time to read it. Fred Ordway followed, this time with a fair proportion of the books listed in our previous Desirada (*Spaceflight* p. 329 July/August 1982).

Several Institutional Members joined in, including World Data Center A and the European Southern Observatory. Our thanks go to these donors for their expressions of goodwill.

In the realm of singles, Jim Harford, Executive Secretary of the AIAA, provided a book on Space Manufacturing, A. P. Camoesan sent an Agard Conference paper on Fluid Dynamics, a Lunar Orbiter Photographic Atlas (SP 206) arrived from Professor Daryl Schrader, R. A. Hearman offered an out of print BIS book, Charles Sheffield presented a copy of one of his new books while Professor Steward provided two items about the late Professor Goddard. Mitch Sharpe brought up the rear with what appeared to be an unspectacular slim booklet, which turned out to have been written by Tsiolkovsky and published in 1929.

Some booklets came our way too, notably from Dr. R. J. Fryer at the University of Strathclyde, though even a foreign non-member, Mr. H. A. de Koningh waded in to help, this time with some back copies of NASA Facts and other material.

We have not been able to list every donor who has made gifts but only those representative few who spring immediately to mind. Our sincere thanks, nonetheless, are extended to every member who gave us books and other material.

Visit to Institute of Astronomy Library

A fascinating time was had by those members of the Library Committee who visited the Library of the Institute of Astronomy at Cambridge. This was originally founded as the Library of the University Observatory in 1823 and augmented since by donations of historically important books, notably by some of its early directors. Over the last 150 years there have been successive amalgamations with other, formerly separate, libraries with the result that the present collection is one of the foremost specialised collections on astronomy, astrophysics and cosmology.

At the last count there were some 8,000 volumes of periodicals and 3,700 monographs which, together with maps, pamphlets and archives, occupied about 1 km of shelving. About 350 bound volumes are added to the collection each year.

All this was too much for the Library Committee members

A visit to the Institute of Astronomy Library in Cambridge helped the Library Committee to see what the BIS Library needs to fill the gaps.

so it was decided to tackle things piecemeal, each member examining the collection in an individual room. The result was a fascinating insight into what constitutes a major astronomical collection nowadays, with quite a few pointers to help us in developing our own specialised Library. This was the main object of the exercise and in that it succeeded admirably. Dr. Dewhurst, the Institute's Librarian, was particularly helpful and gave freely of his time and advice to make sure our stay proved as fruitful as possible.

Slides and Tapes

Steady, if not spectacular, progress in the slide collection was made with gifts from Professor Griffith, R. A. Hearman and Mr. Kjar of the European Southern Observatory.

On the tapes front, recordings arrived from A. B. Perkins and Jeremy Rose, the latter transported through the good offices of Jon Shamah, coupled with a sack of press releases which helped, materially, to fill the Information Boxes which had hitherto been distinguished mostly by their emptiness.

First Day Covers

Our hitherto tiny collection was augmented by a giant boost from Rex Hall, who donated 40 Soviet Covers for display, additional to those he provided earlier, closely followed by Capt. Bob Freitag with a collection of American space covers, and by Francis Field, one of our earliest Fellows, who also turned up trumps by providing some very rare pre-war philatelic covers. Dr. D. J. Horne rounded things off nicely. He was off on a trip to America and asked what he could bring back. "First Day Covers" was our response. He obliged with a dozen or more. On learning about these, Ray Sweetman, a member of the Library Committee, advanced the suggestion that the Society also try to maintain a collection of cards, not postcards but small card collections similar in type and format to those formerly issued with cigarettes. Complete collections of this sort would be very nice to possess, but *where are they to be found*?

Antique Books, Documents and Instruments

The Library Committee is seeking help from members willing to be their eyes and ears in locating a whole range of material not currently featured in our collection.

Members accustomed to rifling through the stocks of second-hand booksellers might be able to keep an eye open for old books on astronomy, stories of space flight or early books on rocketry which could be acquired for a Society Archive Collection. We are particularly interested in books, especially old Star maps, published before 1830 i.e. more than 150 years old. From time to time these turn up, forlorn and forgotten, among collections of books of dubious vintage but they represent items which the Society would find particularly valuable. Members finding such items should ask the bookseller to place them to one side (a small deposit may be needed as a gesture of good faith) to enable them to contact the Society by letter or telephone to check if the particular item is one which the Society seeks. In every case a reply will be given right away.

In Memorium

We were shocked to learn of the death of Ernest Dove, a long-standing Fellow who has always been one of our staunchest supporters, dating back to the time, and before, when he was with the de Havilland Engine Co. Ltd. In a very nice gesture, to commemorate his association with the Society and to link his name permanently with us, his wife Margaret provided a magnificent gift which enabled the

DESIRADA

The list of Desirada published in *Spaceflight* for July/August 1982, page 329 aroused considerable interest, not merely because members were curious to know which items we lacked, even if they hadn't got them, but because it afforded a very good insight on how the Library was developing. The response from members was extremely encouraging. Over a third of the items listed were forthcoming, thus providing representative works, at least, in many areas.

Armed with this, the Library Committee has ventured to produce another list of items it would dearly love to possess. This appears below.

Among those supporting our ventures into the historic past were Fred Ordway, who donated a number of the books we required, with two more American members, George Maziarz and Bob Freitag, chipping in with individual pieces to help complete our giant jigsaw.

Author	Title	Publisher
E. Beer	Vistas in Astronomy (All except Vols 3, 4 & 5)	Pergamon Press
W. Valentine Ball	Reminiscences & Letters of Sir Robert Ball	Cassell, 1915
N. T. Bobrovnikoff	Publications of the Lick Observatory	XVII, part II, 1931
G. F. Chambers	The Story of the Comets	Clarendon Press, Oxford, 1909
J. R. Hind	The Comets	London 1852
D. Kirkwood	Comets and Meteors	Philadelphia 1873
Paul-Henri Michel	The Cosmology of Giordano Bruno	Hermann 1973
MacPike	Correspondence and Papers of Edmond Halley	Clarendon Press, Oxford 1932
C. P. Olivier	Comets	Baltimore 1930
M. Proctor	The Romance of the Comets	New York and London 1926
F. G. Shaw	Comets and Their Tails	London 1893
Prof. S. K. Vsekhsv	Cometography (Physical Characteristics of Comets)	Fizmatzig, USSR, 1958
NASA Technical Translation F15,758	Physical Characteristics of Comets 1965–1970.	NASA

We are constantly searching for new and interesting items for our Library. If you would like to support this work, which can be either in cash or in kind, do please let us know. In the case of books and reports it would be very helpful if we could be given full details beforehand in case we already hold copies.

Ernest Dove, a long-standing Fellow of the Society and a keen supporter of its work from the very earliest days. In Memorium, Mrs. Margaret Dove donated sufficient to the Society to enable it to purchase a copy of "Pyrotechnica" by Babington (1637).

Society to purchase its most treasured possession, a book called "Pyrotechnica" published in 1637. This was a volume the Society would never have otherwise been able to own.

Recently, too, we lost an American member, Thomas Edmund Ashcroft. In a similar gesture, a number of neighbours contributed to a gift of cash to enable the Society to purchase a further volume in his Memory. The volume thus acquired was a reprint of Copernicus' famous work "De Revolutionibus Orbium Coelestium."

AN APPEAL FROM THE LIBRARY COMMITTEE

The Library Committee is always sorry to hear when personal space collections accumulated by members are subsequently dispersed, without the Society been given an opportunity to secure items for its Library.

This is why we would like to bring to the notice of every member with such material the work which the Society is doing both to collect and to preserve records. Some members have already supported this work by giving material to the Society on retirement. The Committee hope that more will do so.

Members who would like to make a gift at some future date, rather than immediately, might consider donating suitable items in their Wills or take steps to make their wishes known to their personal representatives.

Collections of books, personal records, paintings and similar items owned by large institutions today frequently arose because some of their early members donated material which, as time went by, became unique.

Our Society seeks to achieve this position also, but it is only the foresight and support of members which will make this possible. Do help us if you can.

Please advise the Executive Secretary if you envisage making arrangements of this sort.

Artefacts

Just as we were surveying the artefact position with some gloom, Fred and Pip Durant emerged to provide a much-needed shot-in-the-arm. Their mixture consisted of several portions of Gemini and Apollo heatshields, some test specimens, and numerous other space-orientated hardware which brought back the former gleam to our eyes as we considered how a future display of manned space artefacts might look.

PEOPLE AND PLACES

Our "First Night" event last October, during which new members had the opportunity of meeting Society officials and looking around our headquarters, was graced by several distinguished visitors.

One was Science Fiction author Frederik Pohl, for many years editor of the influential *Galaxy* magazine and a BIS member for the past decade. Fred was paying the UK a visit on his way back to the States after a World SF meeting in Linz, Austria (flying by Icelandic Airlines turned out to be the most convenient route!). He reckons on travelling about 50,000 miles a year, with visits to places such as Japan on his itinerary.

Following "First Night", Fred journeyed up to Cambridge to address the University SF Society and managed to get in several plugs about the BIS really keeping its members up to date on what is happening in space.

Another welcome visitor to HQ for "First Night" was Professor John Allen, a former Member of the Council set on renewing some old acquaintanceships.

John had an interesting story to recite about a past BIS meeting. It concerned the meeting at Cranfield originated by the Society in 1961. He tells us that, during the meeting, several people put their heads together. They wanted to plan a long-range missile, Blue Steel, Mk 2. The opportunity to discuss the idea was too good to miss. In fact, the meeting proved so fruitful that it actually and essentially defined Mk 2, which continued under Government spending until the American Skybolt pushed it out.

The concept was for a 19 in (48 cm) diameter ramjet based on the Thor ramjet as used in Bloodhound. As the project developed, a one-sixth scale model was built to prove the concept. It was eventually cancelled because of the alleged superior performance of the Skybolt though this, too, was scrapped in turn.

OBITUARY

It is with great regret that we record the death of Leslie Joseph Johnson of Liverpool in July. Mr. Johnson, a Retired Local Government Officer, was one of the early pre-War members of the Society; in a letter on p. 64 of the February 1981 *Spaceflight* he recalled attending the first informal meeting at P. E. Cleator's home to discuss the formation of an interplanetary society.

CORRESPONDENCE

On the Right Line?

Sir, Eric Waine's article "Space Centre in Vauxhall" *(Spaceflight* October 1979) reminds me of a strange link between a space-faring nation and our adjacent Vauxhall railway station.

In the Russian language, the term applied to a railway station or terminus is a word phonetically transcribed as VOKZAL. The similarity is no coincidence, and stems from a visit made to the area by a Russian technical delegation. They were intent on studying the British railway system which at that time was the longest and most technically advanced in the world.

The head of the delegation asked his guide "What do you call this place?", meaning the definitive term for the building. The British guide mistook the question as an enquiry after the place name and replied "Vauxhall". A Russian scribe dutifully recorded it as such and VOKZAL took its place in their language!

A. T. LAWTON
President, BIS

I Remember

Sir, The letter by "A.NON" concerning "Might Have Been Spaceships" (November issue) makes mention of the 1960 Ideal Home Exhibition and the mock-up spacecraft on display. Because the theme of the show was "The Home", it was felt that a "Home in Space" would be appropriate and so the craft was based on space station plans drawn up by the Douglas Aircraft Co. Details and plans of the station can be found in the NASA publication "Skylab, A Chronology", SP-4011, 1977 pp. 12–14.

ROGER WHEELER
Bournemouth

Might-Have-Been Spaceships

Sir, Though memory dims with passing years, I recall being asked to comment on a coloured frontispiece, designed for a book of a pseudo-technical nature. This featured a dozen different styles of spaceships, winged, wingless, cone-shaped, circular, drum-shaped and odd shaped. All were moving in differing directions and, apparently, at differing speeds. The only thing they had in common was a dangerous close proximity to each other!

The picture was unreal, unearthly, uncanny and quite unacceptable. Unfortunately, I rejected it. This made it unremunerative as well.

A similar situation arose later. This time it concerned "spaceships" on a set of small picture cards to be given away with chewing gum. The cards had already been drawn, printed and captioned by the time the organizer sought approval. The offer was tempting but the cards were too dreadful.

I wasn't paid for that, either!

L. J. CARTER
BIS

Wrong Payload

Sir, In the September/October issue of *Spaceflight* the item "Rocket Experiment Fails" in Space Report (p. 348), contains an error. Mr. Powell is incorrect in stating that the payload of the Water Hole 2 experiment contained water.

In fact, the payload consisted of 120 kg of nitro-methane and ammonium nitrate, a mixture which reacts to produce water, carbon dioxide and nitrogen. The first, similar experiment contained 226 kg of a similar mixture.

G. D. J. DAVIES
W. Australia

Veteran Cosmonauts

Sir, Two recent books on parts of the Interkosmos programme of manned space flights have highlighted information on veteran Soviet cosmonauts still connected with the current Salyut programmes.

The first [1] is a commemorative booklet on the Mongolian space flight of March 1981 and mentions that Gorbatko was assigned as Chief of the Soviet-Mongolian training programme shortly after his completion of duties on the Soyuz 37, Vietnamese flight in 1980. In the same booklet two photos show cosmonaut Volynov (Soyuz 5 and 21) training the Mongolian cosmonauts in water recovery and survival techniques.

The second book [2] is devoted to the pre-launch story of the Soviet-French mission of June 1982. It mentions that Glazkov helped to train the French cosmonauts upon arrival at Star Town. The book goes into great detail of how the men were selected and trained and what experiments they were to perform in orbit. A second book covering the actual mission is to be published.

With recent mention of Glazkov and Volynov we may see these men making near future flights to Salyut 7 or 8.

DAVE SHAYLER
W. Midlands

REFERENCES

1. "Mongolia: Off to a Good Start in Space," Mikhail Chernyshov, Novosti Press Agency Publishing House, 1981.
2. "Spatiale Premiere: Le Premier Francais dans l'Espace," Bernard Chabbert, Plon Books, Paris, 1982.

SNIPPETS

Thanks

Sir, I am writing to thank everyone concerned for the very pleasant evening when I attended the "first night" on 13th October.

Although I have been a member for a number of years it was the first time I had been able to attend a meeting.

J. H. BRADLEY
Merseyside

Worth Every Penny

Sir, Thank you for my copy of "The Eagle Has Wings". Even at first glance it proves to be a magnificent book in the true BIS tradition.

Prof. HARRY RUPPE
Munich

MILESTONES

October 1982

15 The board of enquiry investigating the failure of the Ariane L5 launcher on 10 September concludes that the third stage engine turbopump was the most likely cause. Insufficient lubrication during ground testing might have damaged the gearing. Turbopumps of subsequent vehicles will now have to be modified; the launch of Ariane L6 is now scheduled for April with the ECS-1 communications and AMSAT radio amateur satellites.

16 The 200 in (5 m) Hale telescope at the Palomar Observatory in California makes the first sighting of Halley's Comet on its inward journey to the Sun for the 1985/86 encounter.

18 It is reported that the Japanese space agency is studying the possibility of launching a 650 kg lunar orbiter to make a physical and chemical survey of the Moon. Both NASA and ESA have been studying similar missions but no firm decisions have been made.

21 One of the main engines due to be installed in the Shuttle Orbiter *Challenger* is shut down 51 seconds into a planned 250 seconds test firing because of excessive vibrations in a high-pressure liquid oxygen pump. The full firing is made on the 25th.

23 A more powerful version of the Shuttle Solid Rocket Booster is tested in Utah. It will allow future Shuttles to carry 1,400 kg more payload into orbit.

27 The Satcom 5 communications satellite is launched from Cape Canaveral by a Delta 3924 vehicle. It will be positioned in geostationary orbit at 140°W longitude to provide services for Alaska.

31 The unmanned Progress 16 spacecraft is launched to ferry supplies to the Salyut 7 space station, still manned by cosmonauts Berezevoi and Lebedev.

November 1982

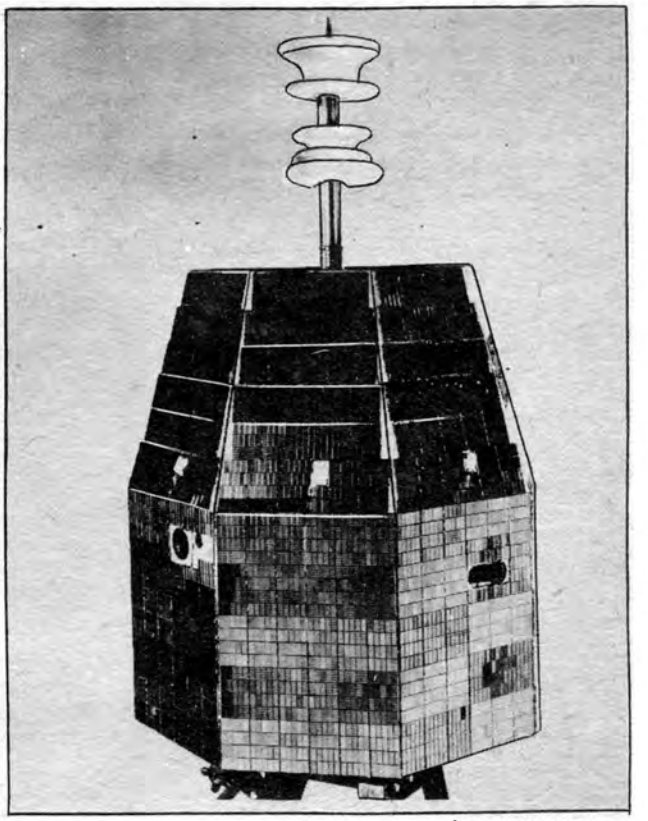
11 *Columbia* is launched on its fifth orbital mission at 12.19 GMT with astronauts Brand, Overmyer, Allen and Lenoir aboard – the first ever four-man launch. Both Solid Rocket Boosters are recovered safely. The first satellite payload, SBS-3, is released from the cargo bay on its way to geostationary orbit.

12 The Anik-C3 communications satellite is released from *Columbia*. Each of the satellites carried $500 million in liability insurance.

15 The first Shuttle spacewalk, already delayed a day because of astronaut Lenoir's motion sickness, is cancelled after an oxygen-circulation fan fails in Allen's backpack.

DO YOU KNOW?

Can you identify this experimental communications satellite, launched in 1962? Along with Telstar and Syncom it helped to establish the extensive network of communications satellites in use today. (Answer below photograph.)



Answer: Relay

DO YOU REMEMBER?

25 Years Ago . . .

1 February 1958. Explorer 1 is launched by a modified Jupiter C rocket to become the first American artificial satellite. (Note: the date at Cape Canaveral was still 31 January).

20 Years Ago . . .

18 January 1963. Bell Aerospace receives a contract to build two manned lunar landing research vehicles to help in training astronauts to pilot Lunar Modules.

15 Years Ago . . .

22 January 1968. The Apollo 5 mission is launched into Earth orbit in the first space test of the Lunar Module.

10 Years Ago . . .

22 January 1973. Ex-President Lyndon Johnson, intimately involved with the US space programme for many years, dies of a heart attack.

5 Years Ago . . .

2 February 1978. Soviet cosmonaut Georgi Grechko, flying aboard Salyut 6 and on his second mission, breaks the record for the total time spent in space by one man: 84d 13hr 20m (held since February 1974 by the three American Skylab 4 astronauts).

ORBITAL TRANSFER VEHICLES

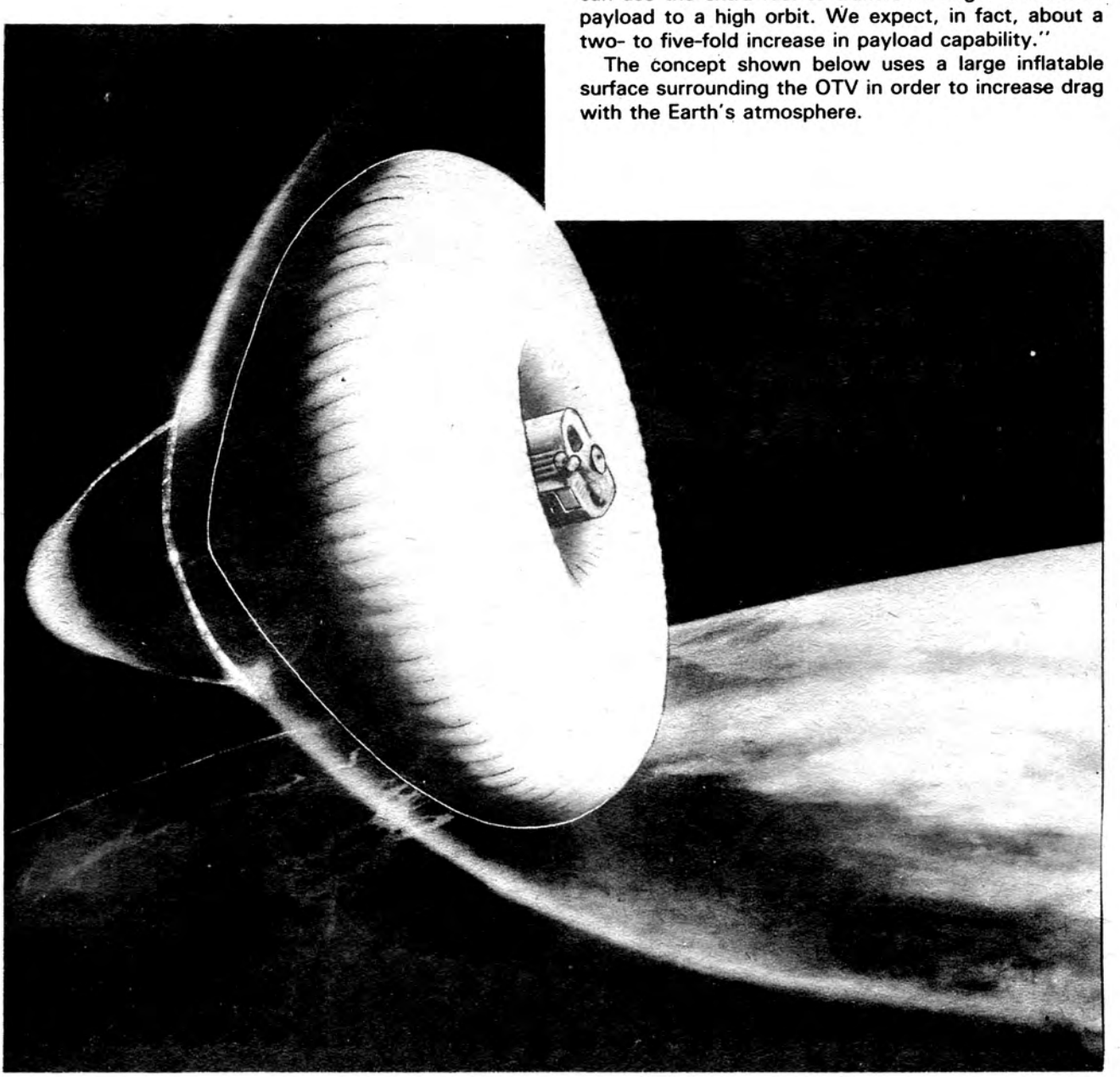
HOW TO SAVE MONEY BY BEING A DRAG

Launching rocket propellant into space is an expensive business. Until it is used to feed an engine for a "burn" it is just so much dead weight. Engineers are always open to suggestions for reducing the quantity needed for any mission and it looks as if we may see a partial solution emerging early in the 1990's.

Orbital Transfer Vehicles – a glorified name for what so far we have called upper stages – will be used by the Space Shuttle to take satellites into higher orbits (the Shuttle itself is limited to quite low altitudes). But the difference between the OTV and previous stages is that it will be able to carry on with other tasks after it has released its primary payload. It may find itself with the job of picking up a malfunctioning satellite and bringing it back down near Earth for retrieval by the Shuttle. And that is where the fuel-saving technique of "aeroassist braking" comes in. Instead of dropping down from a higher orbit and having to use its engine to slow down, an OTV could skim through the outer layers of the atmosphere to lose energy and pop back out into a low orbit.

NASA's Marshall Space Flight Center is currently directing studies on OTVs, having recently selected Boeing Aerospace and General Electric for further work. "We think the vehicle would carry about 40,000 to 60,000 lbs of fuel", said study manager Gene Austin, "and by saving ourselves one rocket engine firing we can use the extra fuel to transfer a larger amount of payload to a high orbit. We expect, in fact, about a two- to five-fold increase in payload capability."

The concept shown below uses a large inflatable surface surrounding the OTV in order to increase drag with the Earth's atmosphere.



TRAINING BELOW FOR WORK ABOVE

By John Bird

Working in space beyond the protection of a spacecraft cabin is still a complex and dangerous business. American and Soviet astronauts spend hundreds of hours practising the work in large water tanks to simulate the weightlessness of orbital activities. With the advent of the Space Shuttle, the Neutral Buoyancy Simulator in Huntsville has become a vital tool for preparing astronauts for such work. Here is a first-hand account of what it is like to go into space a few feet under water . . .

Underwater

There I was, floating outside the cargo bay of the Space Shuttle. It was tiring to work in weightlessness, particularly while wearing a bulky space suit. Was I really out in space? No. I was underwater in a huge tank, known as the Neutral Buoyancy Simulator, at the Marshall Space Flight Center in Huntsville, Alabama. It is often used by astronauts and engineers to practise working in weightlessness.

I was taking part in an evaluation of the procedures used to set up a "space platform". To gain familiarity with tank tests, I was first sent in with Scuba diving gear to observe a tank "run". Since the tank is totally above ground, I took the lift up to the surface where I met the NASA divers who were also preparing to dive. We checked the pressure in our air tanks, then I donned my tank, mask and fins. It was a pleasant surprise to jump into such warm water after training for this dive with wet suits in cool Canadian lakes.

Below me, as I descended, was a full scale model of the Space Shuttle. The roof was opened, exposing the cargo bay which ran the length of the fuselage. Inside, there were two astronaut subjects wearing space suits, accompanied by their many support Scuba divers. It seemed as though we were all floating in space; the water was so clean it was invisible.

The Remote Manipulator System (RMS) of the Shuttle was controlled by an operator looking into the tank through a porthole. He guided the arm, unfolding a 5 m cube made of tubing (see photograph). It was stacked in the bottom of the cargo deck, with other similar folded cubes.

Breathing with Scuba gear creates quite a noise, but between breaths I could hear the conversation between the astronauts and the test director over the underwater speakers.

"Ready to release your side Steve?" the test director asks one of the astronauts.

"OK here but the RMS is seven inches off centre."

To correct this, the RMS grappling hand was moved over. Then it lifted a cross bar, unfolding the cube.

"We'll have to translate it a bit farther before we can start rotation."

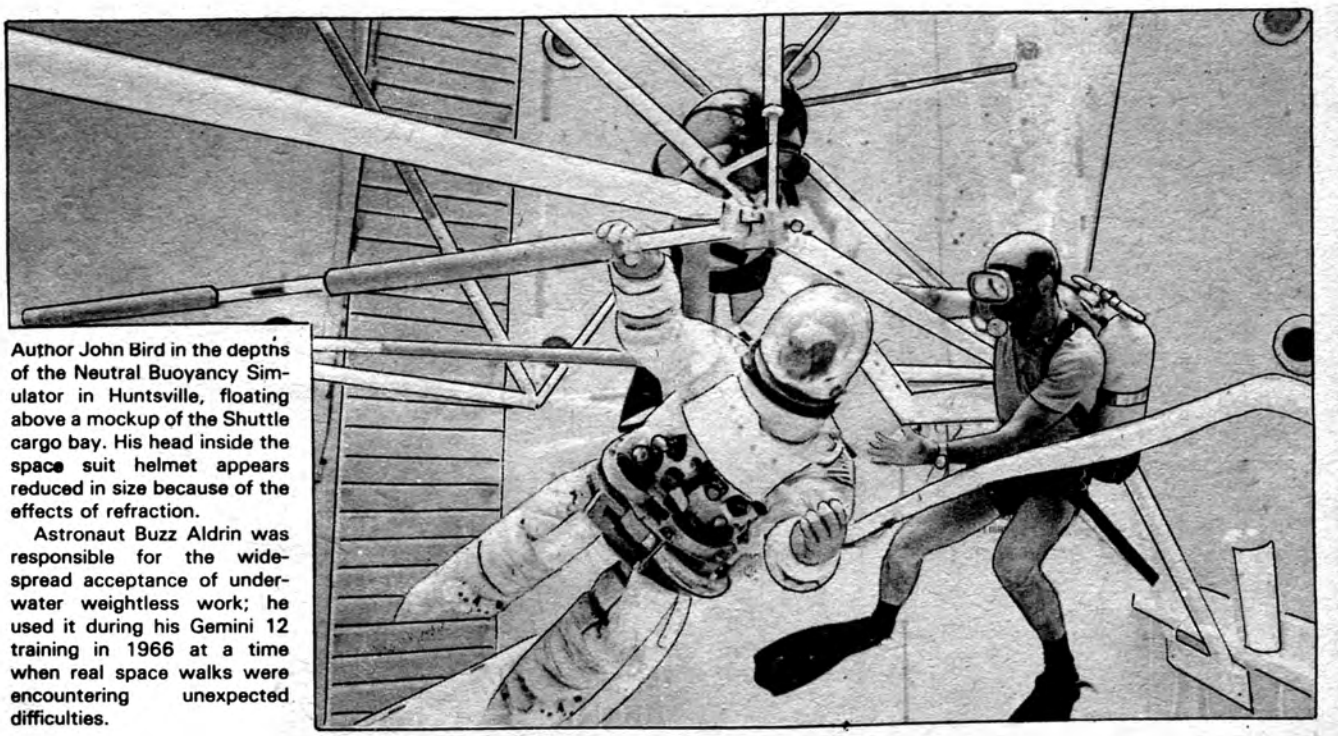
"You'll have to move over to the C-plus side," observed the test director in the control room, as he watched from many angles through TV cameras in the tank. Several people monitor the tank simulations in a large control room full of consoles and TV screens.

"I can't reach it," Steve complained as he prepared to connect two of the cubes together.

"Wait till I strap myself on here. Did you get a good picture, Dennis?" asked Steve as the NASA photographer floated by. There were other photographers in the tank, including a US Navy team and a diver with a mobile TV camera to transmit live close-ups to the control room. Another diver guided the cable from this camera, while yet another held a light for filming.

There were 18 people in the tank. Each astronaut had two safety divers to assist in the event of a suit malfunction. They also watched the line that supplies air and cooling water to the suit, to ensure that nothing became tangled. Another four divers retrieved and positioned equipment. Two additional safety men were on standby, swimming on the surface.

This first dive of mine was made in standard Scuba equipment; now I was ready to wear an EVA suit.



Author John Bird in the depths of the Neutral Buoyancy Simulator in Huntsville, floating above a mockup of the Shuttle cargo bay. His head inside the space suit helmet appears reduced in size because of the effects of refraction.

Astronaut Buzz Aldrin was responsible for the widespread acceptance of underwater weightless work; he used it during his Gemini 12 training in 1966 at a time when real space walks were encountering unexpected difficulties.

Into a Space Suit

Although I had been previously trained in space suits, there was more to learn about the safety procedures for using them underwater. Glenn Dobbs, my suit technician, has been working with astronauts for a long time.

He explained that when working with a suit underwater, a perfect fit is essential. Otherwise, the wearer could end up "bouncing" around inside the suit. So, before my tank run, I went through a sizing check. Each suit is custom-made to fit one of the astronauts, but slight adjustments can be made. I was helped into a suit used by one of the Skylab astronauts and the proper length of the arms and legs were recorded so that slight adjustments could be made later.

Next to my skin I wore a liquid cooling garment, which carries 100 m of tubing to circulate cooling water. This particular one had been worn by astronaut Pete Conrad. He is now in, what he told me, a more challenging career trying to sell DC-10s. He obviously had his own way of doing things: the cooling garments are not made with collars, but he wanted one so he made his own and sewed it on.

Wrist bands were also worn as protection from rubbing on the metal couplings where the gloves were attached. When my space helmet was on, I could maintain my discussion with Glenn *via* the "Snoopy Cap", the communications carrier with earphones and microphones. Last to be put on were my helmet and gloves which had double locks so they could not accidentally disconnect.

As soon as the helmet was locked on the suit began to pressurise, inflating like a balloon. It became rigid and could only bend at the shoulders, elbows, waist and knees where there were joints. Also, the wrist section is free to rotate.

Glenn gave me a dexterity test to demonstrate some of the difficulties involved in working with the suit on. Using a screwdriver was difficult because the glove fingers were wide and did not bend much.

After checking the suit at higher pressure, Glenn brought it back down to ground pressure. A glove was taken off first because, if the helmet were to come off first, a slight excess pressure could send it flying away.

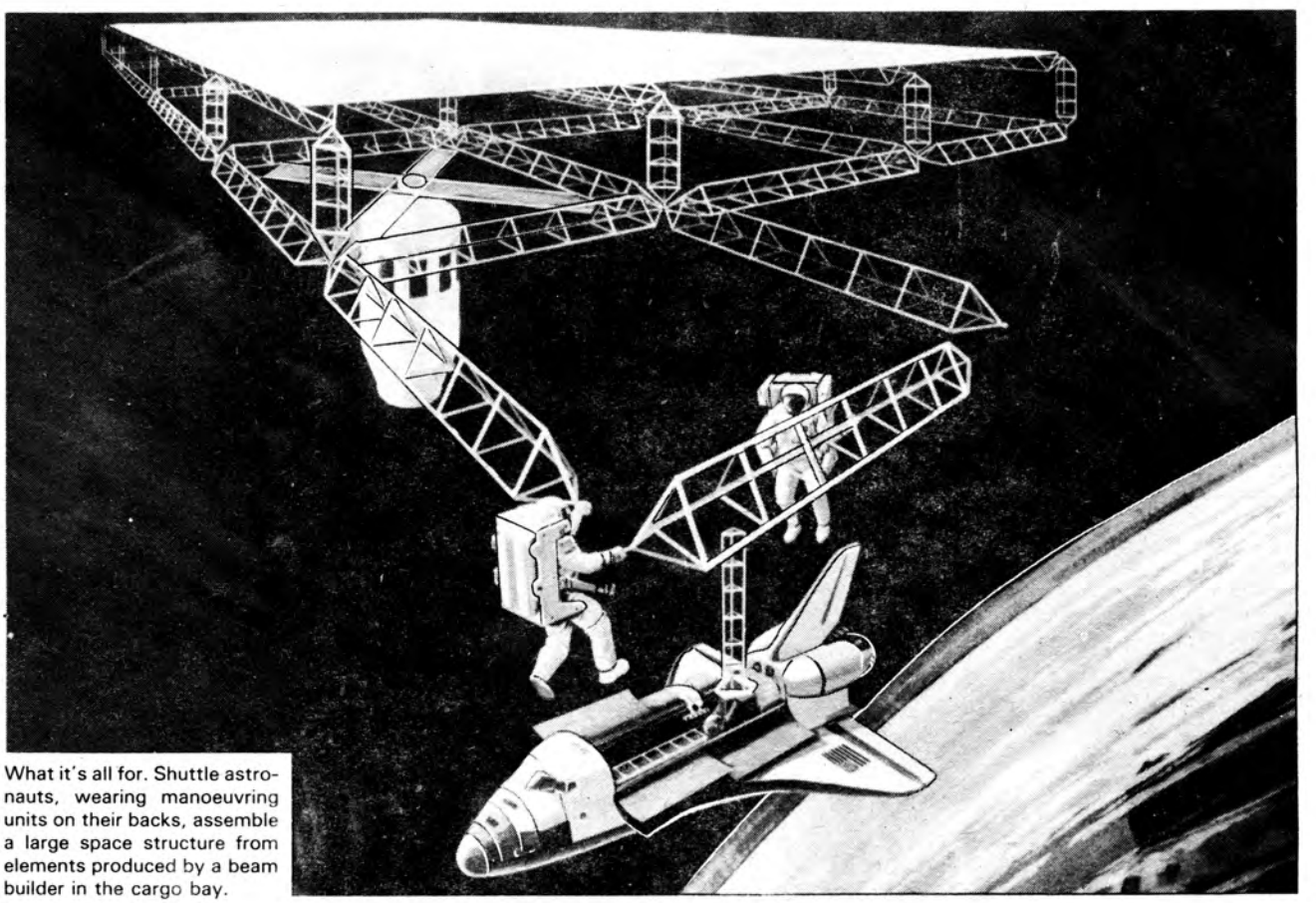
A few days later, I was ready. This time, I was the astronaut and more than 20 people were involved in the simulation. Normally only 15 are required to support a single suited diver, but others were needed to tape styrofoam to some tubes that had leaked and filled with water.

A heart rate sensor attached to my ear was monitored in the control room, but they were having trouble picking up the signal. Adjustments were made and the signal improved. Meanwhile, technicians attached weights to my ankles and wrists to hold me down in the water. Before I entered the water, a communications and status check was made.

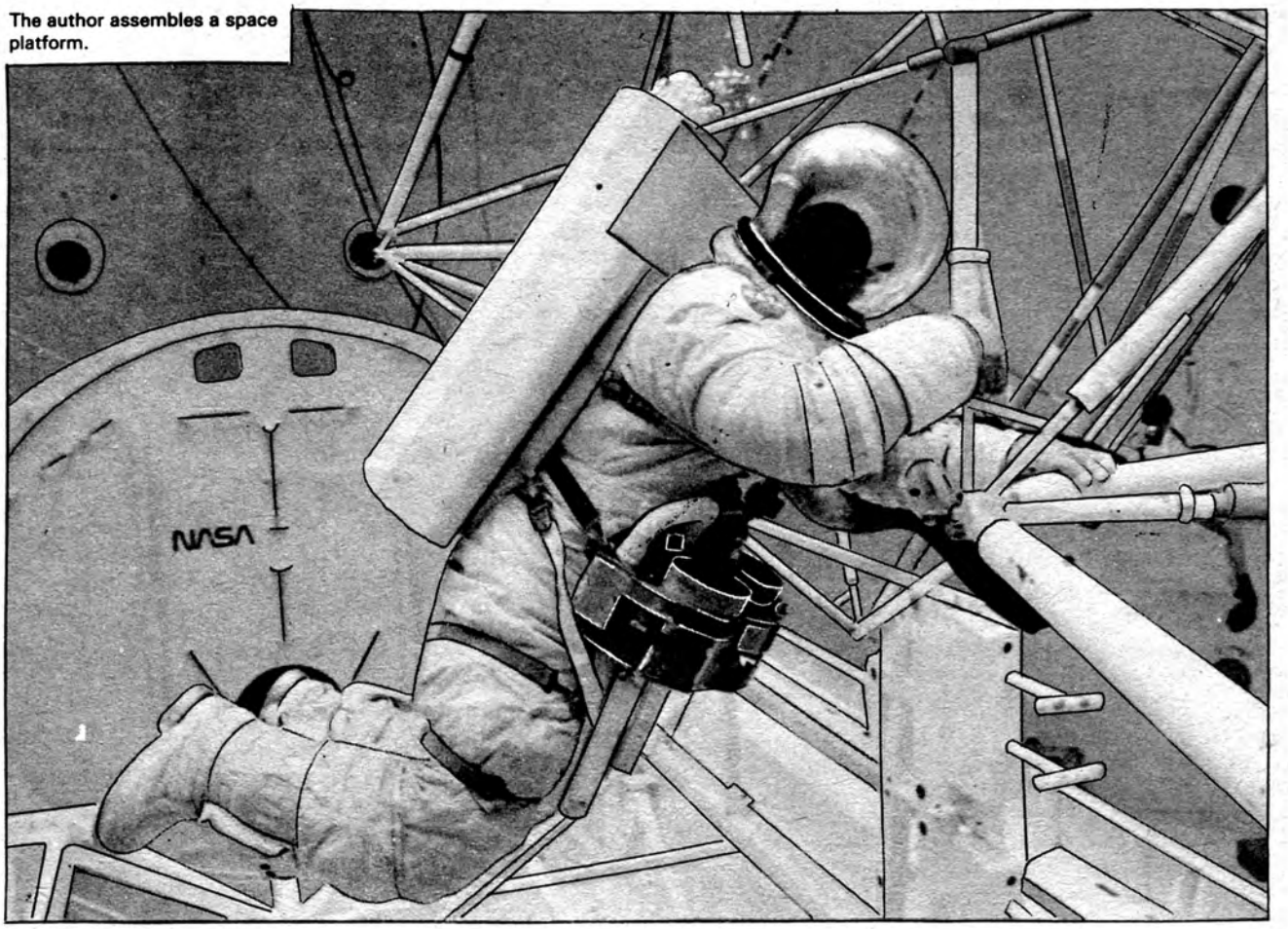
"OK John, three p.s.i."
"Copy. Equalized."
"Deck Chief?"
"Roger."
"Systems Engineer?"
"Go."
"Glenn?"
"Ready."

The list went on as I was guided down a flight of stairs into the water. While I stood partially submerged on a platform, weights were added to my chest, and my backpack was attached. By then, I carried 67 kg of weights to hold down the inflated suit! As I submerged onto another platform, I was amazed to be underwater yet totally dry. Neither sinking nor floating, I was in a state of neutral buoyancy. I was suspended.

To balance my suit, the divers "trimmed me out". They rotated me so that I was lying flat to check that I didn't tip to one side, then they spun me upside down. Assured that I was



What it's all for. Shuttle astronauts, wearing manoeuvring units on their backs, assemble a large space structure from elements produced by a beam builder in the cargo bay.



The author assembles a space platform.

trimmed, they pushed me out and down towards the Shuttle. To maintain the air pressure inside the suit at a pressure higher than the surrounding water, the suit pressure was increased as I descended. Every three metres we stopped to allow my ears to adjust to the higher pressure. This gave me a chance to look around and appreciate the excellent view afforded by the bubble helmet. Being accustomed to the restricted view of a Scuba diving mask, it was a new experience.

Handrails along the outside of the Shuttle made it easy to move around using a hand-over-hand method. Once I began to move in one direction, I would maintain that course with almost no effort other than making sure I didn't let go. A few times I did and I would drift back a bit. Optical distortion underwater makes things look closer than they really are, so a handrail that semed to be within reach was sometimes too far away. I would then be stranded; one of the safety divers would give me a push.

Generally, working in the suit takes some adjusting to because of the restrictions on movement. For example, to reach something above, where one can normally just reach up and grab, is not possible in the suit because the shoulders do not rotate forward easily. But that does not mean it cannot be reached. In fact, in weightlessness it's easier. I could simply push myself "up" and then reach forward. The work is not more difficult, but definitely different.

Sometimes it is more convenient to work upside down. With the suit and extra weights, I had a mass of 152 kg! So, a large effort was required to turn over.

Footholds are provided at workstations in the Shuttle cargo bay and slipping space suit boots into them is a skill that takes practice. Before I tried this, I was tipped forward by a safety diver to have a good look at the grappling system; then I was tilted back up. I was then floating just above them. I had to push my body "down" along a straight line, hook my boot toes in, and turn my heels out slightly. At first, I didn't even know I was hooked in because the platform flexed slowly. Only one of my boots was in and when I tried to put the other one in I ended up tumbling away. But, I eventually succeeded.

To attach an experiment to the Shuttle, two metre long "card table legs" had to be unfolded. I found that it took only a very small force with one hand to swing the large tubes

Sometimes, moving one of these tubes would start me rotating randomly. This was hard to stop unless there was something secure to hold on to. The safety divers made sure I didn't crash into the equipment because sharp edges could rip the suit. Also, the equipment was actual space hardware scheduled to fly in two years to develop the technology for building large structures.

Although suspended in the water, I was not actually weightless. My inner ear could tell my brain which way was up. I could recognise the difference beteen this and true weightlessness, having experenced the latter in fast aircraft. Still, the difference is subtle. Psychologically, I could develop a sense of up and down in true weightlessness. Conversely, working in the tank, I would sometimes forget which way was actually up. But up and down was neither here nor there. In the tank, as in space, I could work with my body in any orientation.

At one point, I looked past my feet and I could see the sky through the skylights in the roof. It was like working on the experiment in space, looking down on the Earth. It was time to leave the Shuttle and the safety divers pushed me up slowly. The sky beckoned. The hardware was ready to fly.

SATELLITES TO THE RESCUE

The international search and rescue satellite project, COSPAS/SARSAT, has located four accident sites and saved seven lives in its first month of operation. COSPAS located two "downed" aircraft in Canada, one in New Mexico and a capsized catamaran off the coast of New Endland.

The Soviet Union's COSPAS satellite was launched on 30 June 1982 as part of the international COSPAS/SARSAT demonstration project in which the United States, Soviet Union, Canada and France are using space technology for finding civil aircraft and ships in distress.

As part of the programme, the US will launch a weather satellite (NOAA-E) carrying a search and rescue capability in February.

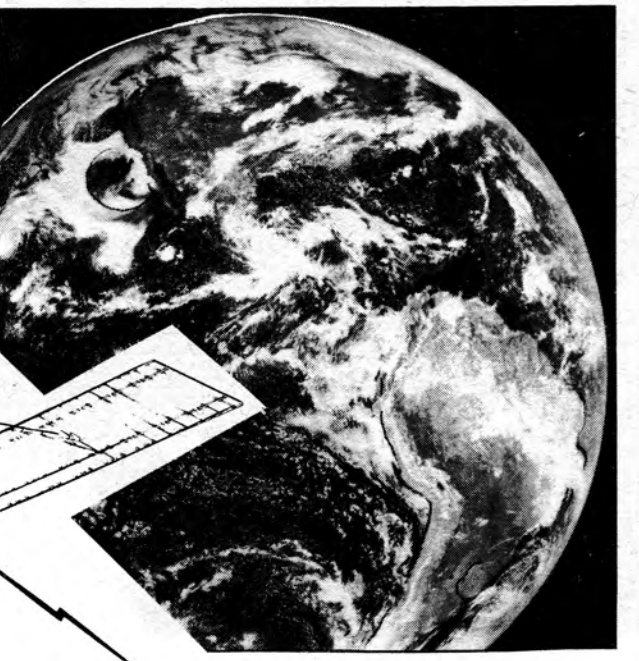
The first effort was early in September, when the father of a missing pilot crashed while searching for his son in British Columbia, Canada. The Rescue Coordination Center (RCC) at Victoria, B.C., was notified that the flyers were missing. The RCC called Ottawa to see if any satellite data might be available. On the next satellite pass over that area early on the morning of 10 September data were processed and an emergency locator transmitter was detected.

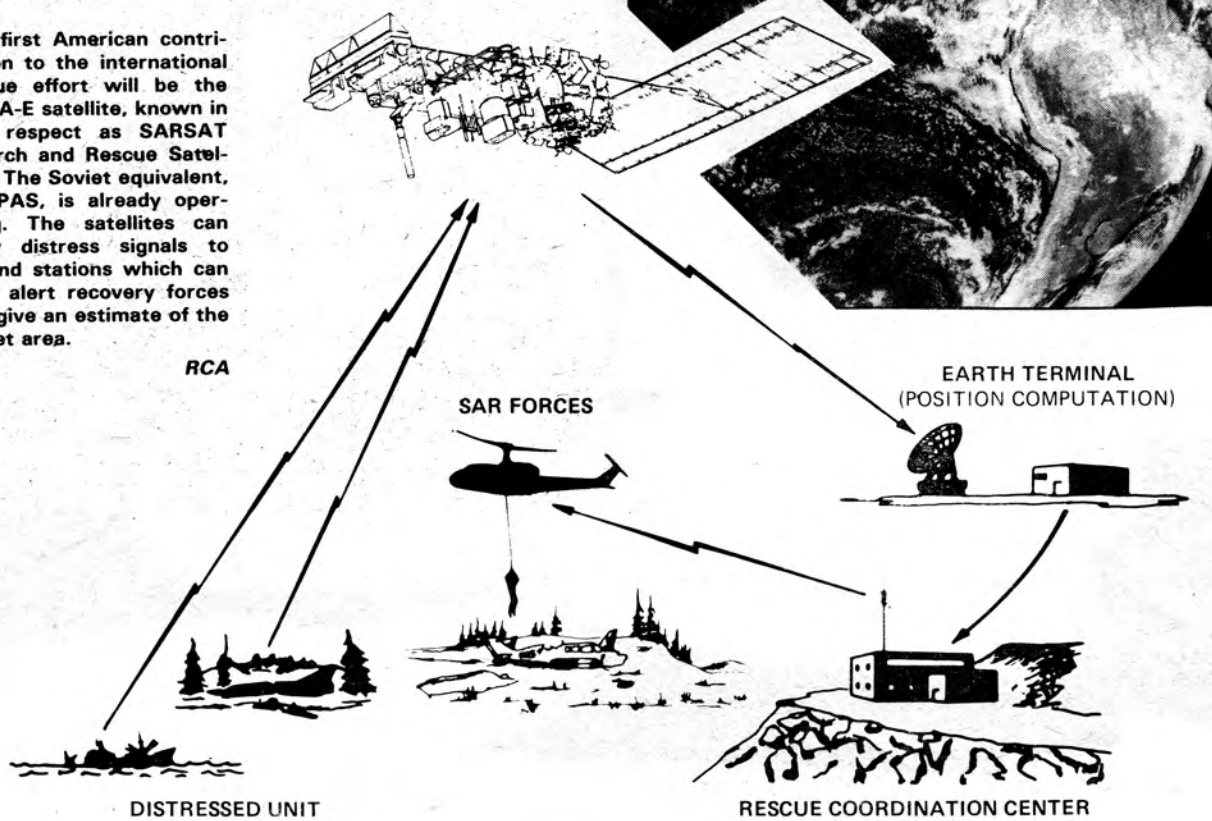
A search aircraft was dispatched to the predicted location and, almost immediately, detected the emergency transmitter. All three passengers had suffered serious injuries but had survived.

The second rescue came on 29 September when Canadian authorities received a Mayday radio call from the pilot of a private 'plane. A spotter aircraft responded immediately to search for the crash site. While the spotter aircraft was in flight, the authorities on the ground got through to COSPAS through the Ottawa Local User Terminal.

As the satellite passed over the Quebec area, it detected a faint transmission from the aircraft and repeated it to the ground station, where analysts calculated the crash site coordinates. The coordinates were then passed on to the spotter aircraft which radioed back the accident location to search and rescue teams. Within 2½ hours after the first Mayday call was received the rescue teams reached the downed 'plane. One pilot had survived.

A crash in New Mexico on 30 September killed both flyers but the COSPAS satellite did provide information to would-be rescuers accurate to within 6 miles. The three occupants of a capsized catamaran were more fortunate on 10 October. Their distress signal was picked up by COSPAS on a pass over the Atlantic and they were rescued within 24 hours.





The first American contribution to the international rescue effort will be the NOAA-E satellite, known in this respect as SARSAT (Search and Rescue Satellite). The Soviet equivalent, COSPAS, is already operating. The satellites can relay distress signals to ground stations which can then alert recovery forces and give an estimate of the target area.

RCA

THE LARGE FORMAT CAMERA

A NEW TOOL FOR EARTH OBSERVATIONS

By Petter Hesselberg

Introduction

Observations of the Earth have been an important aspect of space activities to date. For example, weather satellites have revolutionised meteorology. Another important role has been played by Earth recources satellites; they have contributed significantly to our knowledge in many areas, such as agriculture, forest management, hydrology, pollution control, and mapping of recources.

Most notable in this respect have been the Landsat 1 and 2 spacecraft. They have been used mostly for what is known as thematic mapping, that is, classification of land according to use and cover. By repetitive coverage, they have been able to follow seasonal and climatic changes.

Classification of terrain is accomplished by analysing its reflectance and emission in several spectral bands. The requirements are a near-vertical view (which implies a narrow field of view), a constant illumination angle, the use of multiple spectral bands, and a relatively coarse resolution. This latter is because the smallest areas that need to be resolved generally are the size of cultivated fields; resolution in the 100 metre range suffices.

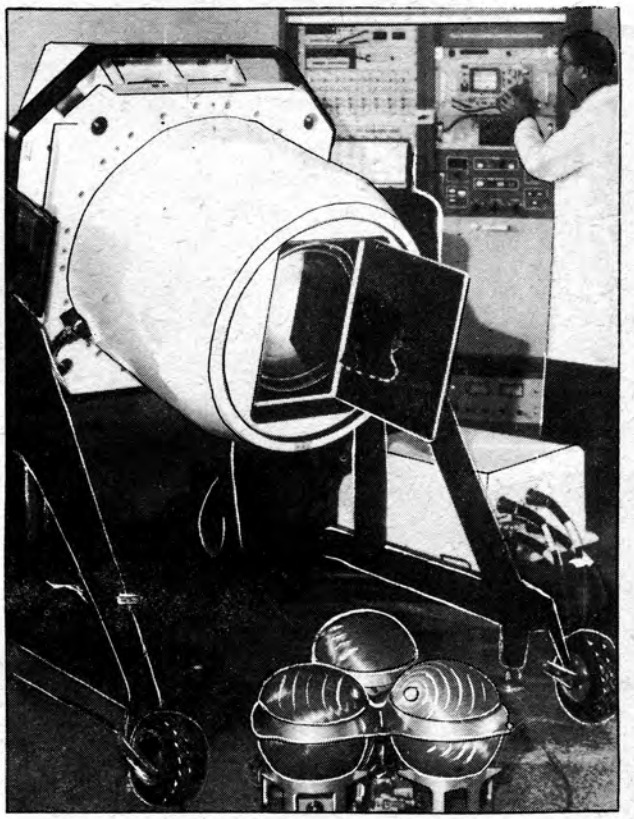
The Large Format Camera

The Large Format Camera (LFC) is a new tool for Earth observations, intended mainly for use with the Space Shuttle. Made by the Itek Corporation for the NASA Johnson Space Centre, it measures 128 by 66 by 89 cm and weighs 430 kg.

The camera will be of great use for geological exploration, topographic mapping and environmental monitoring. The frame format is a large 23 by 46 cm, with the Film Magazine Assembly carrying 1,220 m of film.

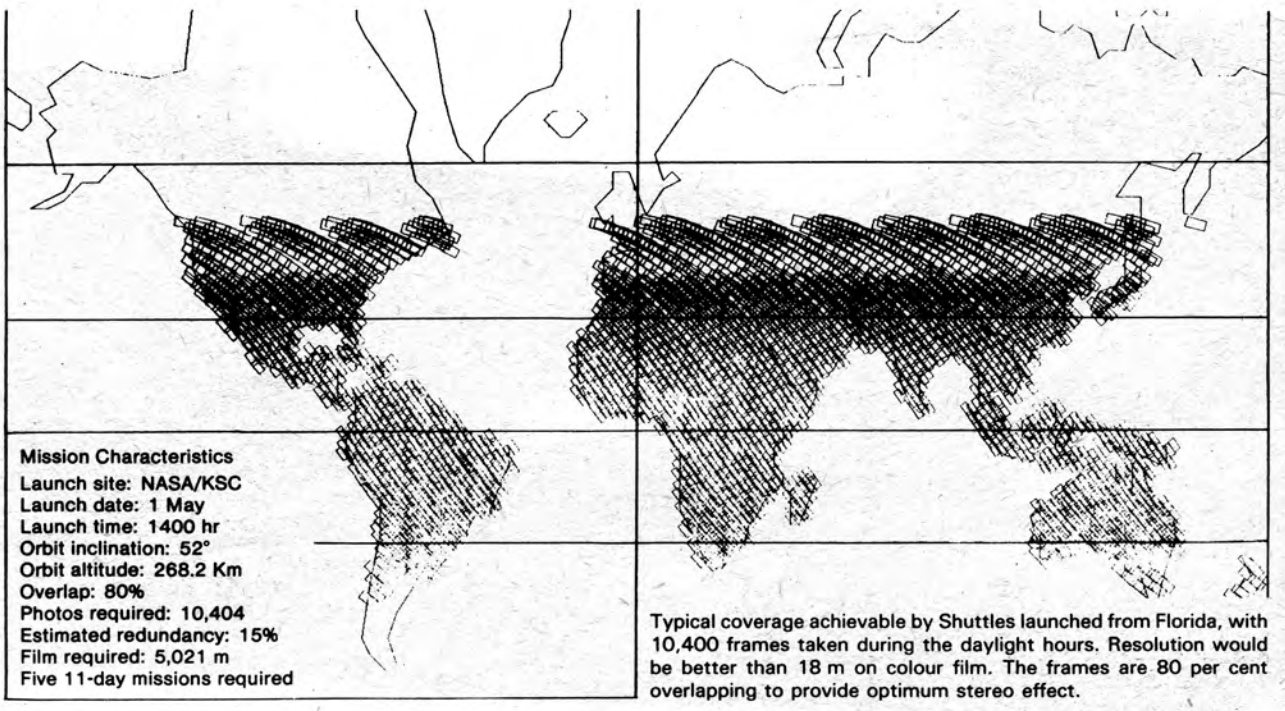
The heart of the LFC is a Metritek-30 lens with a focal length of 305 mm. It has been shown to produce better than three times the resolution of conventional lens designs, giving about 90 lines/mm on fine grain film.

Although the LFC is designed to be carried in the Shuttle

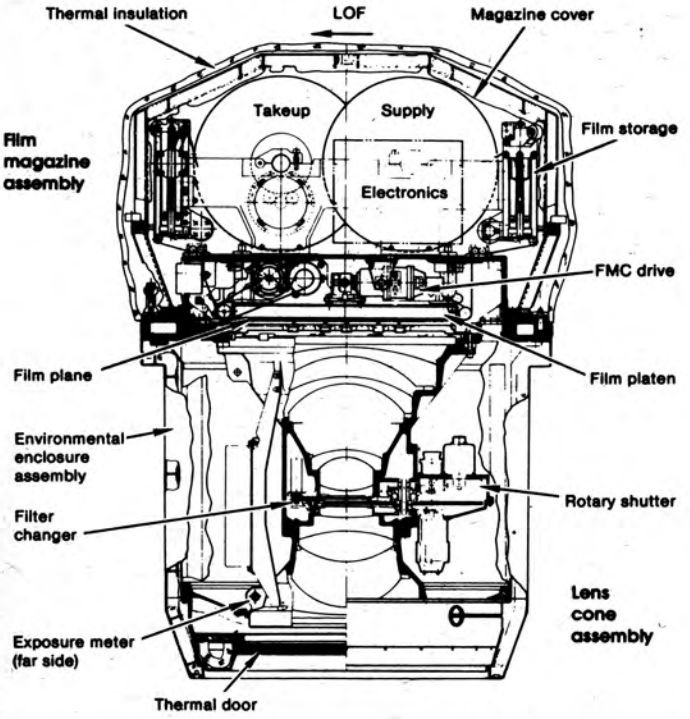


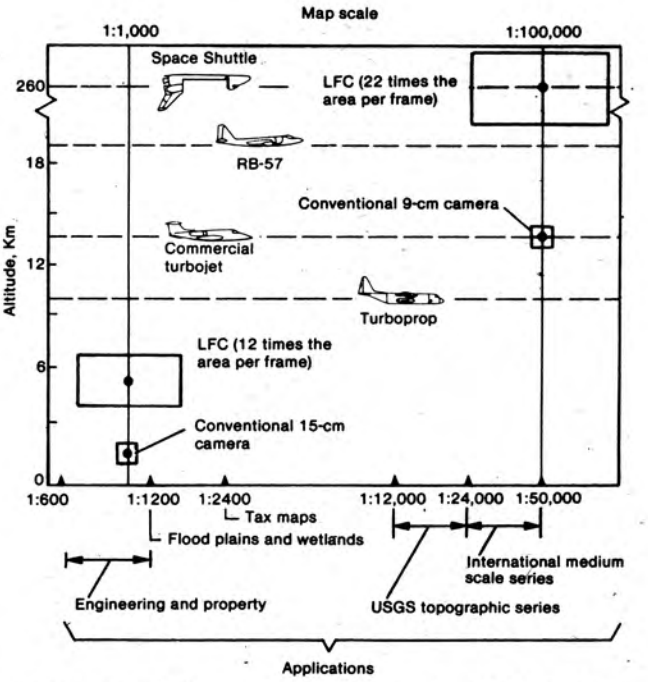
The Large Format Camera. The camera, its electronics module (seen above at right) and the three spherical pressure vessels would normally be mounted on a pallet for installation in the Shuttle cargo bay.

All figures courtesy of Itek Corporation



Typical coverage achievable by Shuttles launched from Florida, with 10,400 frames taken during the daylight hours. Resolution would be better than 18 m on colour film. The frames are 80 per cent overlapping to provide optimum stereo effect.





An illustration of the advantages of using the LFC instead of conventional mapping cameras in terms of area covered.

cargo bay, there are other possible modes of operation. It can, for instance, be carried aboard a Multi-Mission Spacecraft (MMS), which would be left in orbit by the Shuttle and retrieved later. It would be possible to carry enough film to photograph the Earth's entire landmass. It will also be possible to carry the LFC on aircraft to produce photographs with the same resolution achievable at present but covering much larger areas.

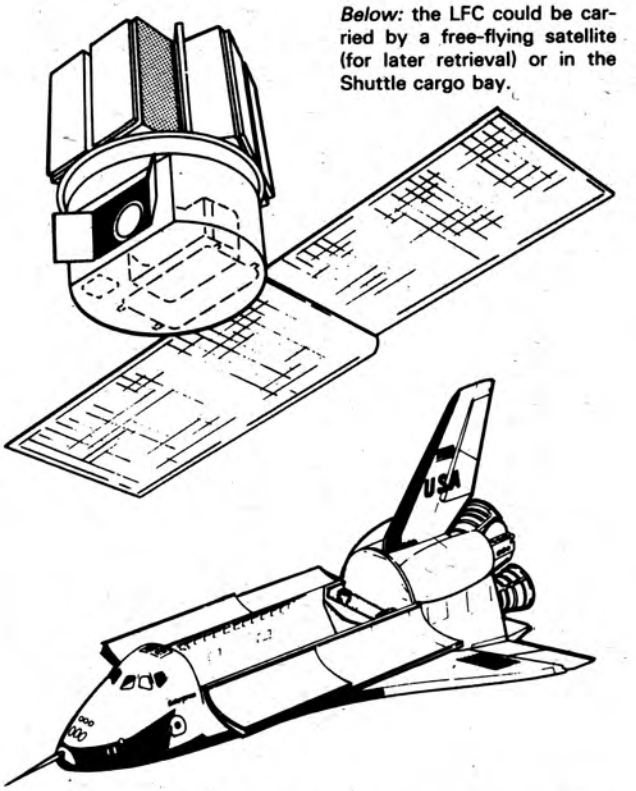
In its first missions, the Space Shuttle will be launched from the Kennedy Space Center in Florida. The maximum orbital inclination will be about 57°, and it will be impossible to cover areas far to the north or south. Beginning in 1985/6, however, Vandenberg Air Force Base in California will be available, making polar orbits possible. From a 545 km, near-polar orbit, the entire Earth can be covered with two film loads (cloud cover permitting, of course). In this case, the black-and-white resolution will be about 23 m, better than that of the new Landsat 4 satellite.

The human brain perceives the world as three-dimensional by virtue of having two viewpoints, separated by the distance between the eyes (the stereo-base separation distance). Similarly, when two LFC frames overlap, their common area lends itself to stereoscopic viewing. The addition of a third dimension makes it possible to measure the height of the terrain with some accuracy. The accuracy is dependent upon the ratio of the stereo-base separation distance to the viewing distance. With a ratio of 0.9, relative height measurement accuracy of ±9 m can be obtained over distances of hundreds of kilometres.

The Landsats have been employed mostly for thematic mapping. The primary value of the LFC will lie in topographic mapping; accurate 1:50,000 scale maps can be drawn from LFC stereo images. These images will also be valuable as a complement to Landsat data; while the LFC will not provide Landsat's coverage of dynamic phenomena, its fine resolution will permit refinement of land classification boundaries. LFC photographs will also be valuable for measuring the total area of fields under cultivation, and in determining surface slopes, hydrological features and soil types of new agricultural areas.

Geological exploration is another field that will benefit

Below: the LFC could be carried by a free-flying satellite (for later retrieval) or in the Shuttle cargo bay.



greatly from LFC images. Not only may we find oil and mineral recources that otherwise might have been missed, but the time and cost expended before these new-found recources can be exploited will be reduced. Experienced petroleum engineers estimate that the percentage of dry holes drilled during the exploitation of an oil field can be reduced from 50 per cent or more to about 20 per cent with comprehensive geological mapping from overhead photography.

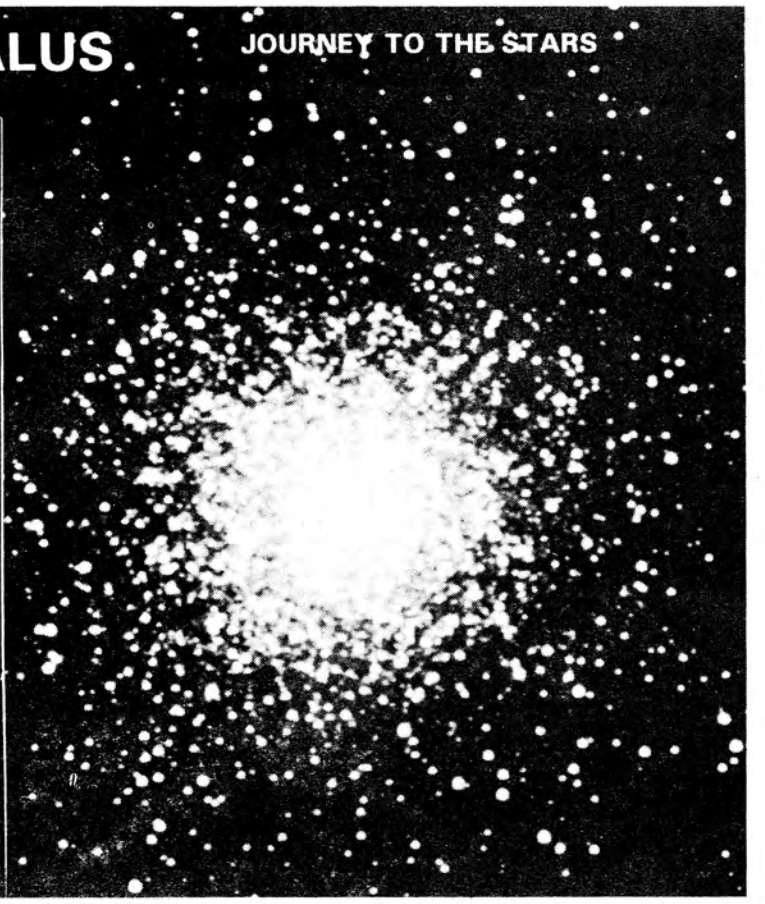
PROJECT DAEDALUS.

JOURNEY TO THE STARS

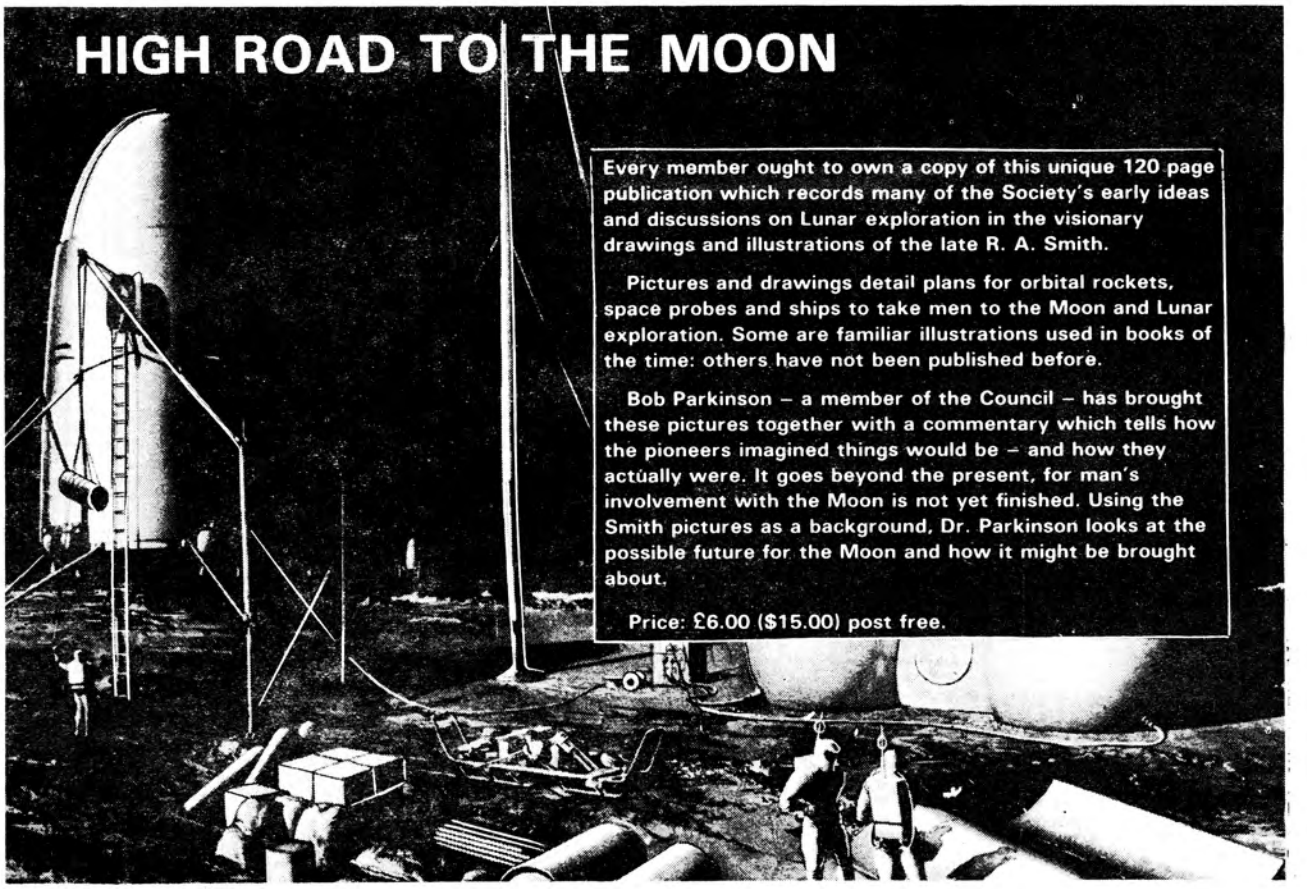
The publication of the Project Daedalus Final Report marked the end of years of painstaking work by a group of BIS pioneers. The BIS received congratulations from around the world for its far-sighted project: designing a probe using reasonable technology for man's first crossing of interstellar space.

The Final Report contains 24 papers spread over 192 large-format (A4) pages, summarising the four year study. The papers cover the overall spacecraft design, mission profile, computer systems, navigation, experiments and our knowledge of nearby stellar systems, some of them possibly with planets.

"Daedalus" is acknowledged as a milestone in the development of advanced astronautics. Copies of the Report cost just £7.00 ($16.00) post free, from The Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ, England.



HIGH ROAD TO THE MOON



Every member ought to own a copy of this unique 120 page publication which records many of the Society's early ideas and discussions on Lunar exploration in the visionary drawings and illustrations of the late R. A. Smith.

Pictures and drawings detail plans for orbital rockets, space probes and ships to take men to the Moon and Lunar exploration. Some are familiar illustrations used in books of the time: others have not been published before.

Bob Parkinson – a member of the Council – has brought these pictures together with a commentary which tells how the pioneers imagined things would be – and how they actually were. It goes beyond the present, for man's involvement with the Moon is not yet finished. Using the Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.

Price: £6.00 ($15.00) post free.

PIONEER CLOSE ENCOUNTER

Two of NASA's most venerable spacecraft, Pioneers 8 and 9, had a "close" encounter (by space standards) when they passed within 1.5 million miles of each other on 7 October 1982. The still operating solar satellites have been circling the Sun since 1967 and 1968, writes Gerald Borrowman.

Two similar satellites predating these sister ships are Pioneers 6 and 7, launched in 1965 and 1966. Also in solar orbit, they are still transmitting information on the space around the Sun.

Designed to last at least six months, these four Pioneer craft have far exceeded expectations. They have been orbiting the Sun for a total of 62 years, and have collectively travelled over 36,000 million miles. Pioneer 6 is man's longest-surviving craft in interplanetary space.

Together, the four spacecraft make up a network of solar weather stations encircling the Sun. Despite occasional equipment malfunctions, the rugged satellites measure the magnetic and electric fields of the Sun and planets, and the high energy cosmic ray particles in space.

These early Pioneers are tracked by NASA's Deep Space Network only when other, more modern, missions don't interfere. However, data on current solar activity maintain its interest.

During the "close" encounter, tests were done to check the recalibration of Pioneer 8's solar wind instrument, which was damaged shortly after launch. Transmitted measurements of the solar wind were compared with those from an identical instrument on Pioneer 9, about an hour and a half (1.5 million miles) "upwind."

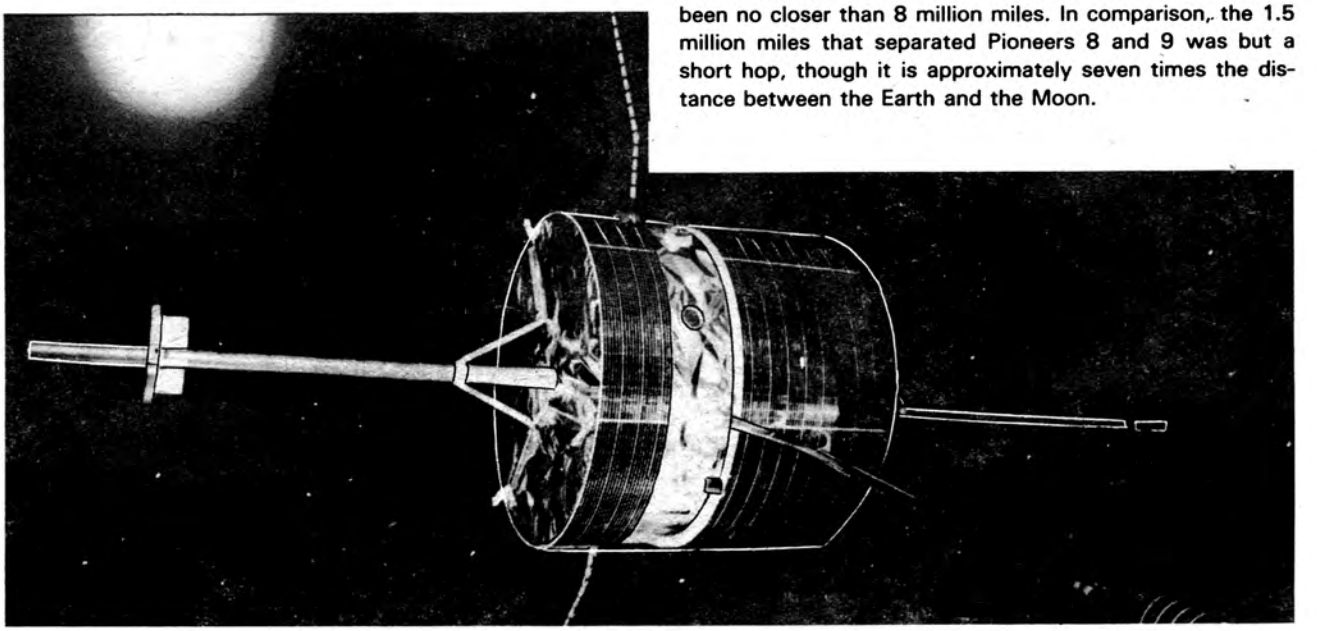
The October encounter was the result of the positions of the crafts in their solar orbits, which average about 180 million miles across. Pioneer 8 was at its point closest to the Sun at the same time as Pioneer 9 was swinging out to its farthest position.

Pioneer 8, launched on 13 December 1967, orbits every 388 days, mostly outside the Earth's own path. Pioneer 9 has been circling the Sun every 298 days since its launch on 8 November 1968 and travels mostly within the Earth's orbit.

Pioneer 8 being mated to the final stage of its Delta launcher, 1967.

NASA

There have been 15 previous occasions when Pioneers 6–9 have travelled near one another in space, but they have been no closer than 8 million miles. In comparison, the 1.5 million miles that separated Pioneers 8 and 9 was but a short hop, though it is approximately seven times the distance between the Earth and the Moon.



SPACE COMMUNICATIONS

NEW INTELSAT IN ORBIT

Intelsat V (F-5), the first Intelsat satellite to carry special equipment for maritime communications, was launched successfully on 28 September. The heaviest of the huge international communications satellites yet to be fired into orbit, the 2000 kg (4,400 lb) spacecraft was launched aboard an Atlas Centaur rocket from Cape Canaveral, Florida.

The satellite was destined for a position in the geostationary orbit at 63°E above the Indian Ocean, providing international telecommunications services to Europe and Africa and the Indian Ocean basin as far east as Japan and Australia and, under a lease agreement with Inmarsat, maritime services for shipping in a similar area. Total cost of the venture (satellite plus launch services) will amount to about $87 million.

Intelsat plans to launch a total of 15 Intelsat V and V-A satellites by 1986. Each Intelsat V has a capacity of 12,000 telephone circuits plus television and each Intelsat V-A will carry 15,000 circuits plus television. Five of the V satellites (F-5 - F-9) will carry Maritime Communications Subsystems (MCS). Each MCS can carry the equivalent of about 30 maritime telephone calls, receiving from and transmitting to ships in the L-band of frequencies. Connections to Inmarsat shore stations are through Intelsat's normal C-band facilities. Under current arrangements with Inmarsat, the second MCS successfully launched will be placed over the Atlantic Ocean and the third will be placed at 60°E to back up the Indian Ocean MCS. There is also an option for an MCS to be placed eventually over the Pacific Ocean.

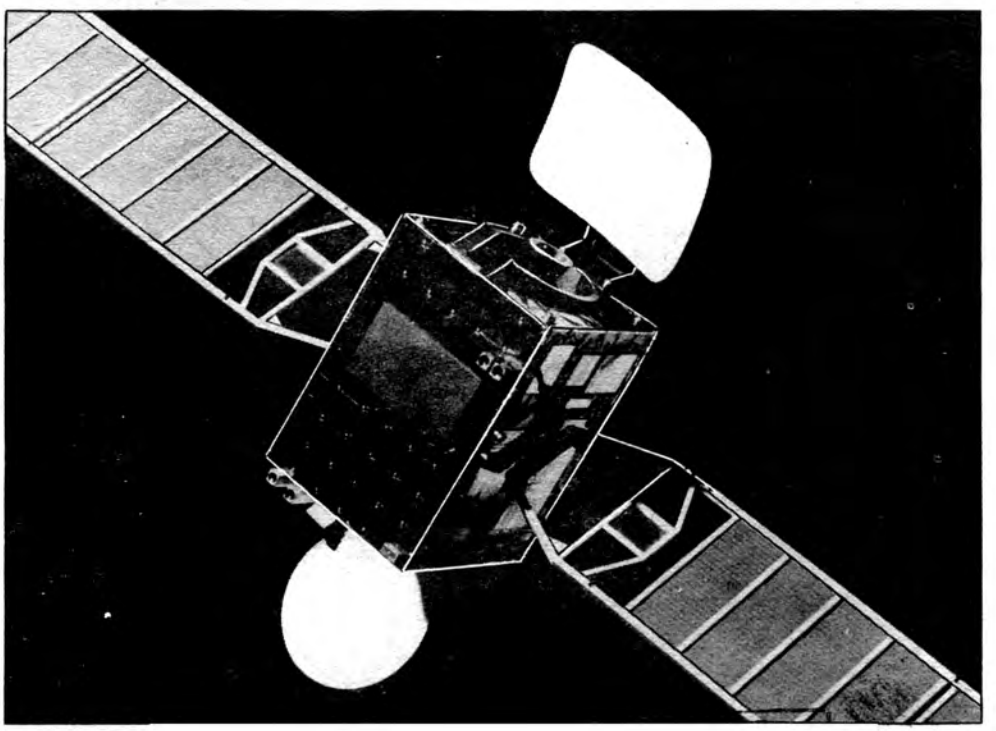
The launch was originally scheduled for 23 September, but was held for 24 hours pending the investigation of a suspected electronics problem. Official decided they needed more time to evaluate data that indicated a possible problem with the solar array drive electronics on a later spacecraft in order to ensure that the problem did not exist on the (F-5) model.

MEXICAN SATELLITE SYSTEM

Mexico is to have a national communications satellite system. The two-satellite system is expected to be operational by mid-1985 and will provide advanced telecommunications services throughout Mexico, including television and telephone to even the most remote areas.

Included in the $92 million contract with Hughes Communications International is a satellite control facility at Tulancingo, northeast of Mexico City.

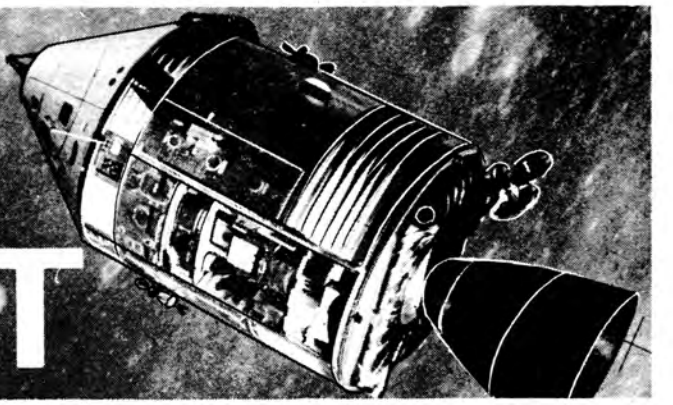
The satellites will carry educational television programmes nationwide, telephone and facsimile services, and data and business transmissions. The two-frequency satellites will operate in the C and K bands with 24 channels. Both satellites are scheduled to be launched by the Space Shuttle in 1985, and have a mission life of nine years. They are versions of Hughes' HS 376 models, bringing the total ordered to 27.



Two 690 kg Arabsat communications satellites will be launched in 1984 to provide services for the 22 Arab League countries.

Aerospatiale

SPACE REPORT



SEEDS OF DISCOVERY

One of the experiments destined for space aboard the imminent Shuttle STS-6 mission won't grab any headlines around the world. The experiment calls for about 40 lb of vegetable and flower seeds to be placed in a two-chamber container which in turn rides inside a small Getaway Special "can." That's all. There will be no attempt to sprout any of the seeds while in flight, no measurements taken, no moving parts.

The purpose of the project is not to determine if seeds will sprout and grow in space. We already know that. A more basic question is being asked – do seeds require special care or packaging to arrive in space in a viable state?

Plant growth experiments in the past have used elaborately controlled containers to hold seeds or sprouts in transit. Such care is expensive and difficult. The Park company, one of the country's largest seed producers and sponsors of the experiment, wants to learn if simpler, lighter containers might work just as well.

The seeds are divided into species, ranging from African violets to garden beans, and placed in several types of packages. Included are airtight plastic bags and loosely sewn dacron bags.

Half of the seed packs will be carried in a hermetically sealed inner chamber with normal air conditions. The remaining packages will be placed in a surrounding chamber which will be vented to space. During the mission, the latter seeds will be exposed to near vacuum, extreme cold and somewhat greater radiation than the packages in the inner, sealed chamber.

When the day comes that we will be living in permanent space stations, it will be prohibitive to ship food up in bulk. Food and flowers will be grown there from seed. But can we simply throw a bag full of seeds in the back for the trip, or will we have to be more careful?

After the flight, the seeds will be removed and tested to see how they fared. By planting some of them and comparing their growth to that of plants in two control batches, the company hopes to learn the answer to an important question for the future.

MORE SHUTTLE ASTRONAUTS

NASA has decided to relax some of their requirements for flying people aboard the Space Shuttle. Until now, flight opportunities for Payload Specialists have been offered to customers buying a half or more of a Shuttle mission or who were flying a unique experiment needing the unique talents of a particular scientist or engineer.

Under the expanded programme, to begin in 1984, that will change. Flight opportunities for Payload Specialists will be made available whenever possible on a reimbursable basis to all classes of Space Shuttle major payload customers, including foreign and domestic commercial customers, international cooperative partners, the scientific and applications community and the Department of Defense.

On the first four flights of the Shuttle, there were two crew members aboard, the commander and pilot. The fifth carried four, adding two Mission Specialists, who helped in deploying two commercial communication satellites.

In the future, Mission Specialists, who are experts in extravehicular activity, operation of the Remote Manipulator System and payload support systems, will be joined by Payload Specialists on specific missions. They will be added to selected flights to provide detailed, on-the-spot expertise concerning payloads or scientific experiments. They will most often be scientists, with special skills to operate a scientific experiment, or a specialist proposed by a Shuttle customer trained in the critical aspects of deploying and operating a satellite.

Proposed Payload Specialists will undergo a short training period in preparation for flight. NASA will retain final selection authority to insure that they are fully qualified and can work as part of the flight crew.

VOYAGER 2 PRESSES ON

The Voyager 2 spacecraft has now travelled about one tenth of the distance it must cover for its encounter with the planet Uranus, projected for 24 January 1986.

In the five years since its launch on 20 August 1978, the probe has travelled 3000 million km and is now 1700 million km from Earth. Most of the science instruments are functioning well after more than 40,000 hours of operating time.

Sixtyseven of the original 104 kg of propellant remain to be used for attitude control and trajectory correction. The two radioisotope thermoelectric generators are furnishing 422 watts of electrical power, which is 92 watts more than the requirement. The two areas of concern are one scan platform actuator which is showing signs of wear and the radio receiver which has reduced tracking capability. Neither of these problems is expected to seriously affect the future encounter with Uranus.

Mission controllers at NASA's Jet Propulsion Laboratory in California are in daily contact with the spacecraft as its

science instruments monitor the interplanetary environment. One-way radio time from Voyager 2 to Earth is now 90 minutes.

Voyager now has sufficient velocity to ultimately escape from the Solar System even though it has yet to fly by Uranus in 1986 and possibly Neptune in 1989. With a heliocentric velocity of 19.9 km per second (44,600 miles per hour), it has the distinction of being the second fastest object made by man. Its sister ship, Voyager 1, is travelling slightly faster.

In its epic journey thus far, Voyager 2 has obtained approximately 32,000 images of Jupiter and Saturn with their rings and 13 major satellites. Planning is already underway for photographing Uranus with its rings and five satellites in 1986.

PLUTO/TRITON DISCOVERIES

Methane, a material that exists on Earth mainly as a byproduct of living organisms and petroleum refining, has been found in the frozen form for the first time on two other bodies in the Solar System – the planet Pluto and Neptune's largest satellite, Triton.

The new findings indicate that Pluto, most distant of the known nine planets, and Triton have surfaces that are very different from any other known bodies orbiting the Sun.

A molecule of methane is composed of one atom of carbon and four of hydrogen. It can exist as a gas as long as the temperature is above 50 K (−370°F). When the temperature falls to 50 K or below, it freezes into a solid.

On Pluto, methane is usually frozen on the surface. The planet journeys far from the Sun during most of its 248-year orbit, but for a few years it travels well inside the orbit of Neptune. Its surface temperature when farthest from the Sun has been calculated as less than methane's freezing point. But when it comes closer to the Sun, the temperature rises to about 65 K and some of the solid methane should turn to a gaseous atmosphere. This has been observed.

The methane on Triton, on the other hand, is solid ice. No sign of gaseous methane was found.

By observing Triton as it moves around Neptune, presenting different faces to Earth, astronomers have deduced that methane ice does not uniformly cover the surface, but exists instead in great continent-sized patches.

Most of the other satellites in the outer Solar System are markedly different from Triton and Pluto; they have surfaces that are primarily water ice. (The single exception is Saturn's largest satellite, Titan, which has a dense atmosphere of nitrogen and methane gas.)

It is hoped that Voyager 2 will be able to make careful, extended observations of Triton when it makes its closest approach to Neptune in 1989.

Neither of the Voyagers will approach anywhere near Pluto, so will be unable to make any observations of that planet. It is possible, however, that an instrument operating in the infrared region of the spectrum aboard NASA's orbiting Space Telescope may be able to observe Pluto in the late 1980's.

The first image from the remote sensing satellite Landsat 4's "thematic mapper" was taken on 20 July last year. It shows the Detroit area near Lake Erie in the northern United States; the mapper was designed to show objects as small as 30 m (100 ft) but it appears to be exceeding all expectations.

NASA

QUASAR DISTANCE RECORD

An international team of astronomers has discovered the most distant object in the Universe. The astronomers, from the US, the UK and Australia, have discovered that a quasar ("PKS 2000-330") is more than 12,000 million light years away.

Light arriving at Earth today from PKS 2000-330 began its long journey here before the Solar System, and probably the Galaxy, was formed.

The search began 10 years ago using antennae of the Jet Propulsion Laboratory's Deep Space Network. Dr. Samuel Gulkis of JPL and Dr. David Jauncey suggested that the DSN antennae could determine accurate positions of radio sources in the sky that might be quasars. They linked the 26 m (85 ft) and 64 m (210 ft) antennae at the DSN's Tidbinbilla tracking station in Australia. They were joined at JPL by Australian Dr. Michael Batty, and accurately measured the positions of a large number of radio sources that had been discovered with the 64 m Parkes radio telescope in Australia.

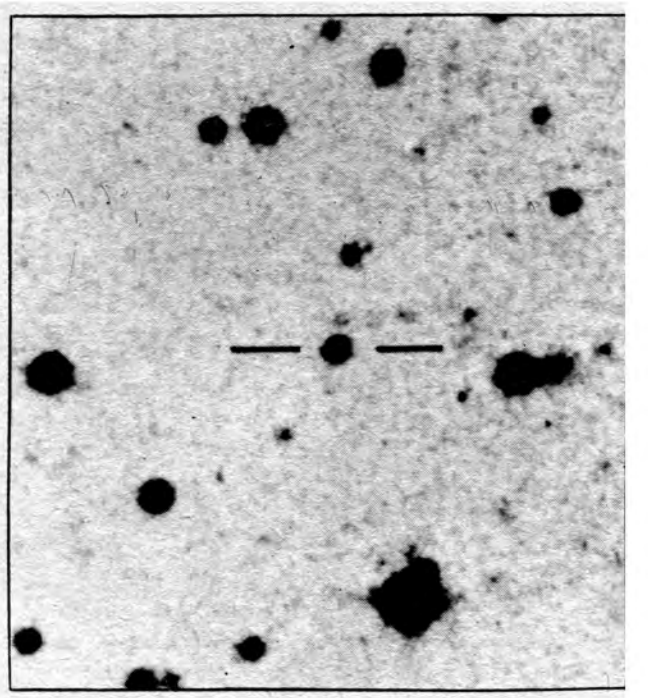
The team was then joined by Dr. Anne Savage, an astronomer from the Royal Observatory, Edinburgh. Dr. Savage matched the radio sources with objects in photographs.

Then Dr. Bruce Peterson of the Australian National University's Mount Stromlo Observatory, together with Jauncey, Savage and Dr. Alan E. Wright, measured the spectrum of PKS 2000-330, using the 3.9 m (12 ft) Anglo-Australian telescope.

On the night of 25–26 March, 1982, the spectrum of PKS 2000-330 revealed emission lines of oxygen, hydrogen, nitrogen and carbon at a red shift of 3.78, greater than any red shift ever measured.

The red shift, a measure of how much a distant object shifts its light toward the red end of the spectrum, is believed to indicate the object's relative velocity away from Earth, and, therefore, its distance. The greater the red shift, the greater the recessional velocity, and the greater the distance from Earth.

Quasars today present one of astronomy's greatest puzzles. They appear to be the most distant objects in the universe. They also appear to be expending vast amounts of energy, much more energy than theory can account for.



Quasar PKS 2000-330 (indicated by the black lines) is believed to be the most distant object yet observed: 12,000 million light years (about 10^{23} km) away.

IMPROVED SHUTTLE BOOSTERS

A high performance booster motor for the Space Shuttle was test fired for the first time last October. The motor has been redesigned to increase the initial thrust of the Shuttle at liftoff, allowing the reusable spacecraft to carry more payload.

According to Frank Adams, deputy manager of the Solid Rocket Booster Project Office at NASA's Marshall Space Flight Center, the thrust increase was achieved in several ways. "To the casual observer, the motor will look the same as those we are presently using. However, we have reduced the size of the 'throat' and increased the length of the motor's exit cone. We have also increased the burn surface of the propellant by removing some of the inhibiter used at the ends of the four centre motor segments," said Adams. "These changes will give the motor a higher specific impulse which increases its performance and thrust."

The higher thrust motors will be used for the first time on the eighth Shuttle flight, now scheduled for mid-1983. The two motors will provide an additional 4 per cent thrust over the motors currently in use which deliver about 2.8 million pounds of thrust (12.5 MN) at liftoff.

Two giant Solid Rocket Boosters provide approximately 75 per cent of the Shuttle's power for liftoff from the launch pad and during the first two minutes of flight. After their propellant has burned out, the boosters separate from the Shuttle and parachute into the ocean where they are recovered and returned to Kennedy Space Center. They are then refurbished and reused on subsequent Shuttle missions.

MARS/MOON MISSION STUDIES

RCA Astro-Electronics, builders of the Tiros and some of the Explorer satellites, have been asked by the Jet Propulsion Laboratory in California to study the feasibility of converting their spacecraft for Mars and Lunar-orbiting missions.

The two satellite concepts are:

- The Mars Geoscience Orbiter (MGO), which would operate for one year in a low polar orbit over Mars and carry a gamma-ray spectrometer, multi-spectral mapper, magnetometer and a radar altimeter.
- The Lunar Geoscience Orbiter (LGO), which would operate for one Earth year in a low polar orbit over the Moon. It would carry the same complement of instruments as the MGO, plus an X-ray spectrometer and electron reflectometer.

The satellites would make a detailed study of the surface and near-surface composition, volatile locations, and the

internal structures of each heavenly body.

The Mars Science Working Group of NASA recommended in the 1970's that a suitable follow-on to Mariner and Viking would be a "Mars 1984" polar-orbiting mission. ESA is also studying its own orbiter mission, Kepler.

ROBOTS IN SPACE

Robots have long been associated with space flight and spacecraft in the popular press. But, except for robotic devices such as the Space Shuttle's remote manipulator arm, the use of robots in space has been limited thus far.

NASA, however, sees a significant potential. The Marshall Center, under funding from NASA's Office of Aeronautics and Space Technology, has been working with the Massachusetts Institute of Technology on a study to see how they might best be used in space. The study addresses both robotics and an even more exotic, related field called "telepresence".

The first phase of this two-part study was recently concluded, according to the Marshall Center's study manager Georg von Tiesenhausen. "The purpose is to make future missions more affordable," said von Tiesenhausen, "by having humans doing only those tasks they do best. Humans have dexterity and can do delicate work, and they are better prepared to deal with unexpected events and make on-the-spot decisions. And humans can intervene when machines fail.

"Machines, on the other hand, can take over failure diagnosis and maintenance tasks, and can do 'housekeeping' – for example, keep the on-board systems running."

In the part of the study just completed, MIT examined three areas. "First," said von Tiesenhausen, "the institute was to investigate what kinds of tasks have been planned in space over the next 15 years or so. Secondly, it was to research the state-of-the-art over the next decade or more. Thirdly, MIT was to match the two – the automation and the tasks – to find for each activity the automation available."

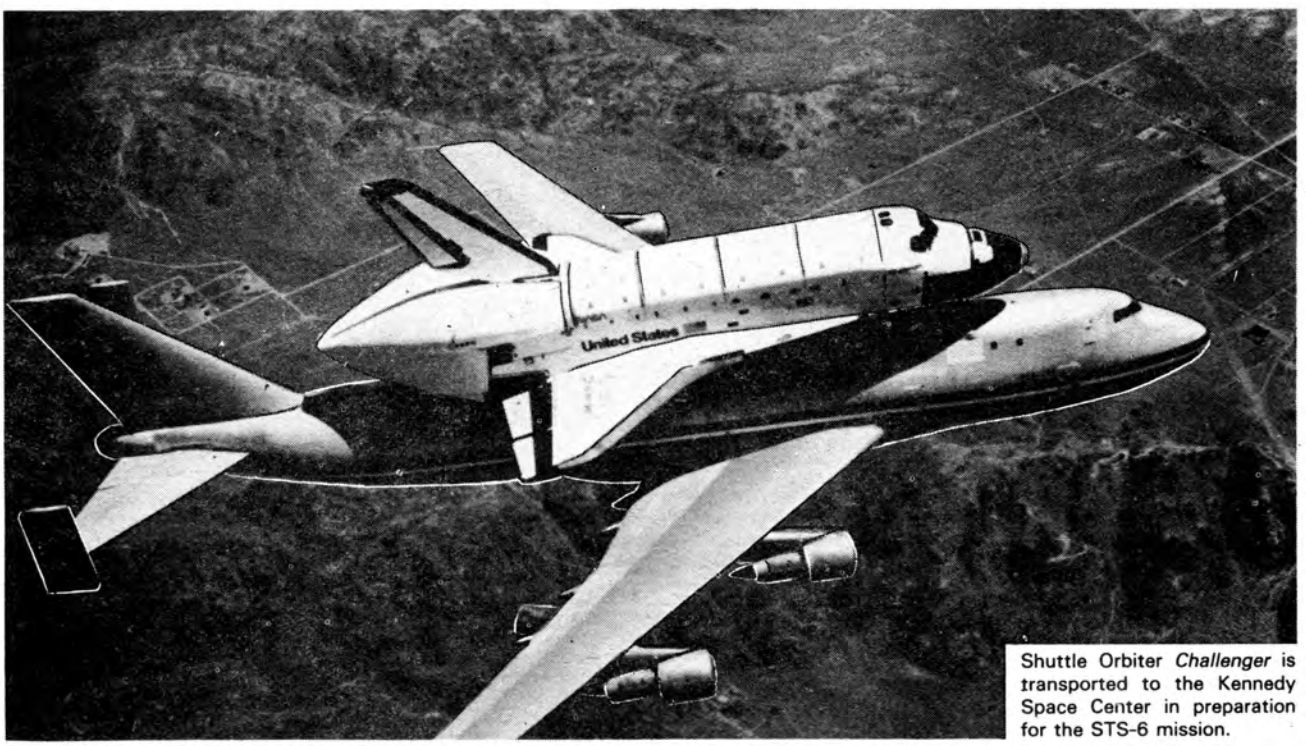
In the study, the institute arrived at some 70 activities that cover a broad spectrum of missions. The activities were then arranged into an organised format. "Marshall is the first to organize the technology of automation," said von Tiesenhausen. "There was no structure within the entire automation community before now."

The second part of the contract now underway concerns "telepresence" and is a specific application extracted from the first part of the contract. "The idea of telepresence evolved from MIT's Marvin Minsky, and the concept involves a lot of automation," said von Tiesenhausen. "The example I'm fond of using is 'driving a car by telepresence': you'd get into a remote control device in New York and drive an empty car through traffic in Los Angeles. In the machine in New York, you would have a lot of sensors strapped to your hands and legs, and you would see what the camera saw from the empty car in Los Angeles. If you turned your head to the left or right, the camera in the Los Angeles vehicle would do the same. With telepresence, you could do things in space as if you were really there."

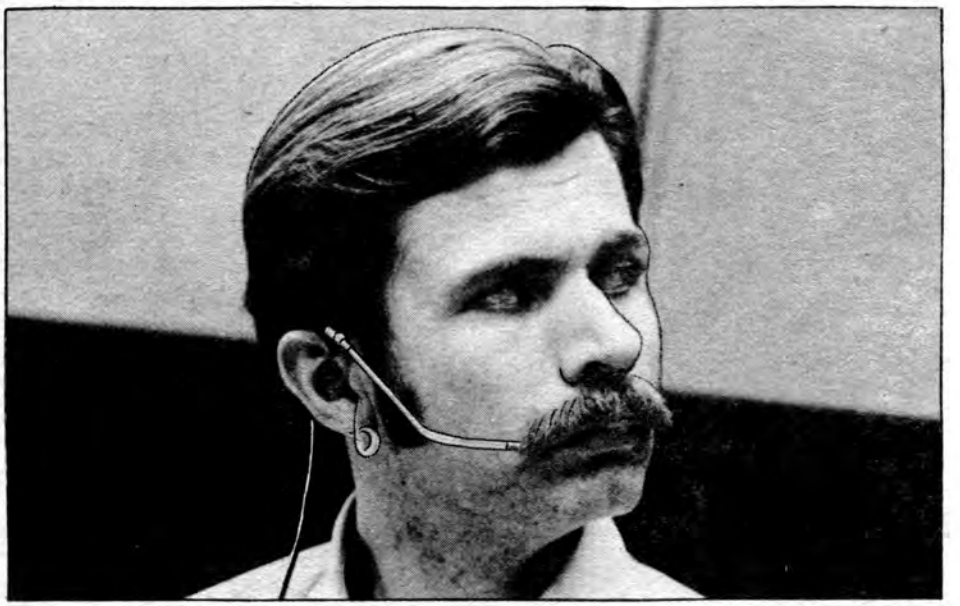
The telepresence half of the MIT study contract will run until next May. It will concern itself with two questions: Based on present automation technology, what technology gaps must be filled in order to build an initial telepresence system and what kind of demonstration programme is needed to verify telepresence applicability to space tasks.

"Our present robotic equipment is much too heavy and clumsy for telepresence," said von Tiesenhausen. "An automated arm, for example, weighs 900 kg. A human arm weighs 4.5 kg and needs only a few watts. That's one of the differences between human and robotic capabilities.

"Technology has a long way to go to close the gap, but this study will take us that much closer."



Shuttle Orbiter *Challenger* is transported to the Kennedy Space Center in preparation for the STS-6 mission.



Dale Gardner will serve as one of the two Mission Specialist astronauts aboard the Shuttle's 8th mission. (*Challenger's* third) this July.
NASA

SPACELAB TUNNELS

Testing has begun at McDonnell Douglas Corporation on a special tunnel through which scientists will move from the Space Shuttle crew cabin to the European Space Agency-developed Spacelab next autumn.

Scientists and astronauts will move through an environmentally-controlled transfer tunnel designed and built by McDonnell Douglas Astronautics Company (MDAC) in Huntington Beach under the overall Spacelab Integration Contract between NASA and McDonnell Douglas Technical Services Company (MDTSCO) in Hutsville, Alabama.

That contract, awarded in April 1977, calls for the construction of three tunnels. The first, completed in October at Huntington Beach, will be used for a series of rigorous Earth-bound qualification tests of its ability to withstand the stresses of launch and space flight.

The tunnels are designed to be used in either of two configurations: a "long" mode of 20 ft (6.1 m) and a "short" version of 8 ft (2.4 m). The longer version will be needed if Spacelab is positioned in the back of the cargo bay to achieve better weight distribution.

SPACE RESEARCH REPORT

A recent report by the Congressional Office of Technology Assessment ("Space Science Research in the United States") is openly critical of present space science planning. It comments:

"Many now see space science as in a state of crisis. The National Aeronautics and Space Administration's (NASA's) overall budget for space science has, in general, been on the decline since 1974, and that of one category, planetary science, has declined precipitously. For the latter part of this period, the space science budget for physics and astronomy has been on the rise, but this increase is largely being spent on a single major project, the Space Telescope.

"As a result, few missions are in prospect: in planetary science, only the major Galileo mission to Jupiter is planned for the 1980's; in solar and heliospheric physics and X-ray and gamma ray astronomy, all major missions have been postponed. Not only have the numbers of missions decreased, but there is insufficient funding for important interim activities such as data analysis.

"Unlike the manned space program, space science has never been directed toward a particular national goal of unequivocal priority. As a result, space science policy has been conducted in a mode where the programs undertaken are determined primarily by available budget and only secondarily by scientific goals. Furthermore, no base budget has ever been set to ensure that certain scientifically critical activities are sustained.

"The current practice of budgeting most flight missions as independent new starts emphasises spectacular accomplishments, and is not necessarily optimal for scientific progress.

"International cooperation in space science activities has been fruitful in the past and, for possible major missions in the future, may be highly desirable in order to share costs. There has been, however, a continuing problem of the United States' changing its commitments to international missions. Potential foreign partners are therefore reluctant to enter future agreements with the United States."

OTA is a non-political agency of the Congress which analyses complex issues involving science and technology for both Senate and House committees.

EX-ASTRONAUT FIGHTS ON

Jack Swigert, 51, has recently disclosed that he is suffering from cancer of the bone marrow. He still continued his campaign for election to the US Congress, despite his recent problem, and a failure in 1977 to be elected, writes Dave Shayler.

He was selected as an astronaut by NASA in April 1966 and served on the Apollo 13 crew in 1970. He left NASA's Astronaut Office in 1973 to enter politics. He takes the news of his cancer in his stride as he did the Apollo 13 near-disaster, "Apollo 13 taught me that challenges are to be met and overcome."

TWENTY YEARS ON

NEW CANADIAN SPACE VENTURE

On 29 September 1982 the Government of Canada formally announced support for a plan to send Canadians into space under NASA's Space Shuttle programme, writes Gerald Borrowman. The announcement was made during a special celebration at the David Florida Laboratory of the Communications Research Centre marking the 20th anniversary of the launch of Canada's first satellite, Alouette I.

The ceremony also marked the formal inauguration of service by Anik-D1, the first satellite for which a Canadian company was the prime contractor.

The celebration was hosted by communications Minister Francis Fox and attended by pioneers of the Alouette programme, leading figures from Canada's space industry, members of Cabinet, and General James Abrahamson, Associate Administrator of NASA, who announced the guidelines for the participation of Canadian personnel aboard the Space Shuttle.

Responding to General Abrahamson's statement, Minister for Science & Technology John Roberts said, "On behalf of Canadians, I welcome this exciting challenge to expand our space interests and knowledge. The Government of Canada is now considering the details for the selection and training of Canadians to fly on the Shuttle."

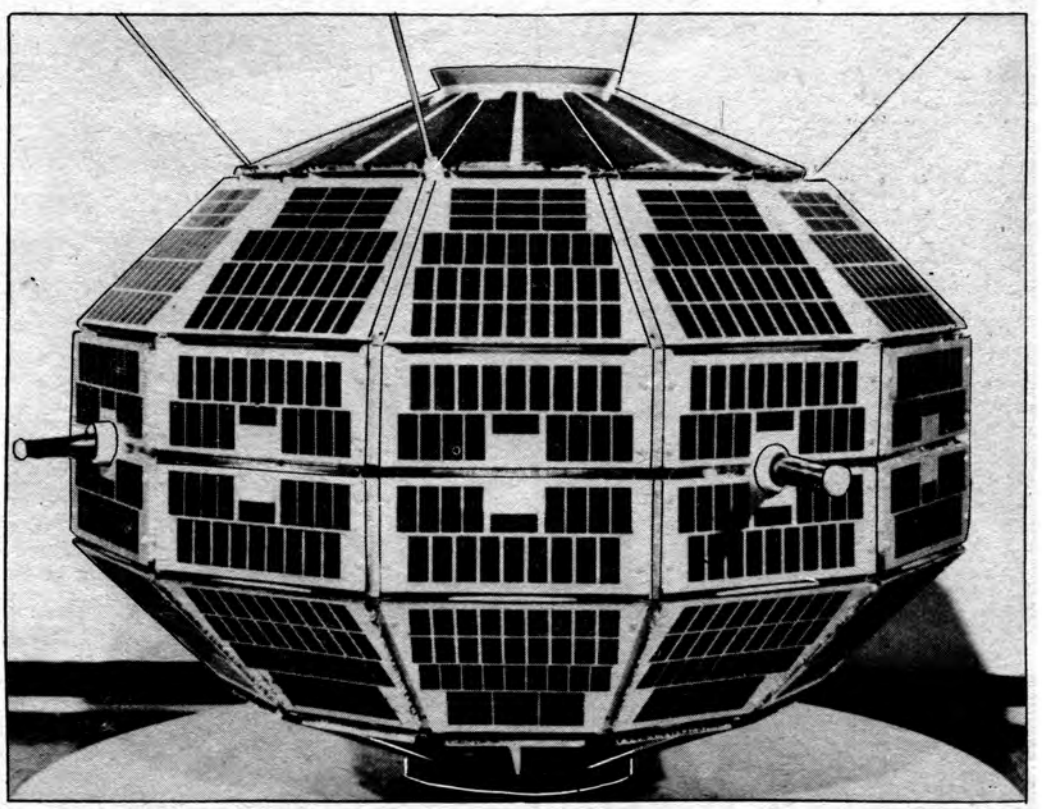
Roberts did not say when the selection process would begin. However, the candidates will have to be physically and psychologically fit and have a suitable scientific background. He estimated it will cost $1 million and require six months to complete the training for a mission. The Canadian Cabinet will be asked to approve funds to begin the selection of up to five Mission Specialist candidates to be trained partly in Canada and partly in the United States.

Mr. Roberts lauded the achievements of the Canadian aerospace community, "Alouette changed this country's perception of the world around us and our place in the world. It showed young Canadians that it was possible to pursue a career in this country at the leading edge of scientific research and applied technology."

Alouette I was placed in orbit on 29 September 1962, making Canada the third country, behind the US and the Soviet Union, to orbit a satellite. The data it relayed helped to lay the groundwork for the network of communications satellites that now links the wide expanses of Canada.

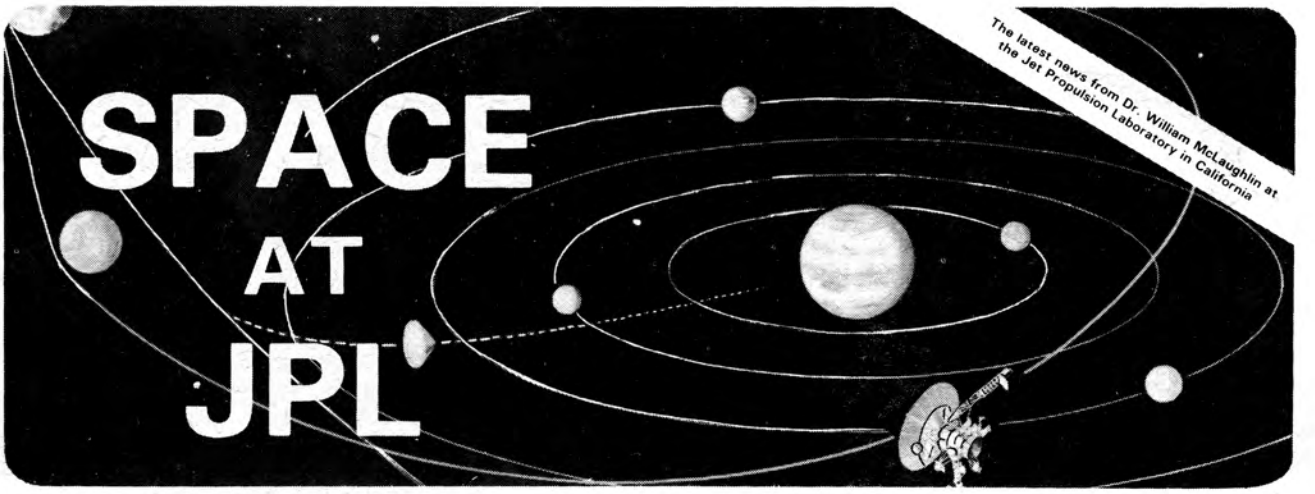
"If Alouette I had failed, I think it would have meant the end of Canada in space," said Colin Franklin, who was chief engineer of the Alouette programme. "A lot of people were waiting to say clean out your desks, let's concentrate on areas where we can succeed." At the time it was launched, it was the most advanced satellite in orbit. Alouette and three scientific satellites launched in later years provided data on radio disruptions at high altitudes and conditions in space.

"Waiting for the launch was pretty gut-wrenching," Mr. Franklin recalls. The US had lost about 40 per cent of the satellites it tried to launch because of explosions during lift off or faulty guidance. "A lot of eggs were in one $3 million basket, but we were confident almost to the point of arrogance. The satellite went into a perfect orbit." In fact, Canada has never had a failure in 10 satellite launches. Today, even the most remote parts of Canada are linked by a system of communications satellites and Earth stations.



The 145 kg (320 lb) Alouette satellite was launched on 29 September 1962 by a US Thor Agena, to investigate the Earth's ionosphere.

NASA



HALLEY'S COMET RECOVERED

The first observation of Halley's comet as it approaches the Sun for its 1986 encounter has been made using the 200 in telescope at Palomar Observatory. The astronomers, led by graduate student David C. Jewitt and staff member G. Edward Danielson, first located the comet on 16 October and verified their observations on 19 October.

The comet was detected at an apparent magnitude of 24.3 when it was approximately 11 astronomical units from both the Earth and the Sun; about 1.5 astronomical units beyond the orbit of Saturn.

Palomar Observatory, like JPL, is operated by the California Institute of Technology, and, in fact, Danielson has been intimately associated with past JPL missions, including the Mariner 9 mission to Mars.

EXPLORER 1 AT 25

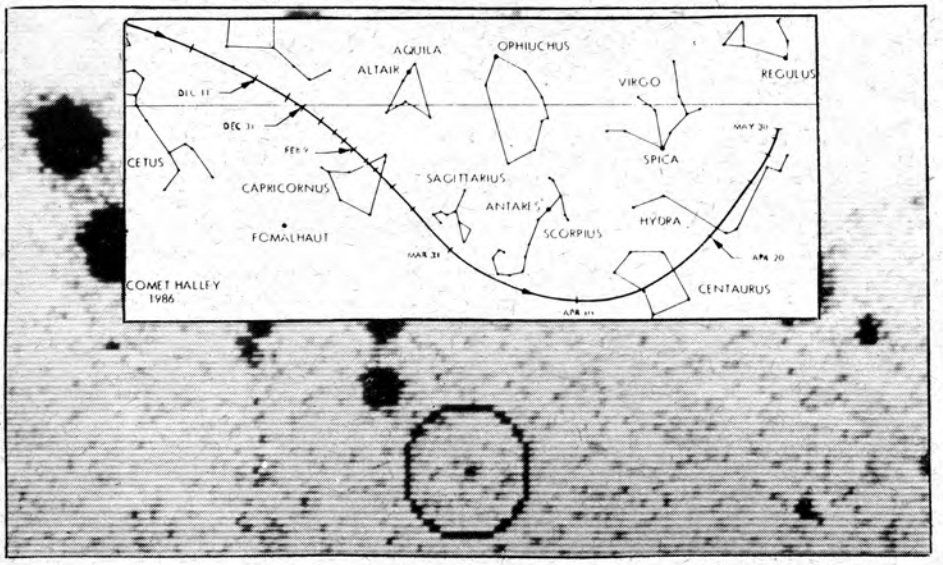
"The winners laugh and joke and the losers cry deal!" This wry observation from the lore of poker playing provided the etymology for "Project Deal": the designation of the JPL portion of the US team which put Explorer 1 into orbit 25 years ago.

After the shock of the Sputnik 1 launch on 4 October 1957, it soon became clear that the Soviet Union was the big winner as the space age began to unfold that autumn and winter. The magnitude of their achievements was underlined by the huge payload delivered into orbit on 3 November with Sputnik 2 and its passenger, the dog Laika. At the same time the official US satellite effort, Project Vanguard, was struggling with a tangle of technical and scheduling problems.

The chronology of events which led to the acquisition of a US space capability, as demonstrated by the orbital insertion of Explorer 1 on 31 January 1958, has been told many times. General John Medaris himself, the overall director of the Army-JPL effort, has given his version in *Countdown for Decision* (G. P. Putnam's Sons, 1960). Recently I sought out a few of the Explorer 1 "survivors" at JPL in an attempt to recapture some of the original flavour from this historic period.

It was natural to start with James Burke. He came to the Laboratory in 1949 and is well-known to readers of *Spaceflight* and *JBIS* as the author of papers devoted to the exploration of the Solar System with particular emphasis upon lunar missions, an area in which he has made important contributions for over 20 years. In recent years he has guided many advanced mission studies at JPL.

Burke did not work on Project Deal as such; at that time



This picture, acquired with the 200 in (5 m) Hale Telescope at Mount Palomar, shows Halley's comet (circled) as it was found by Caltech astronomers David Jewitt and G. Edward Danielson on 16 October 1982. This first picture of the comet since 1911 was captured on a charge-coupled device similar to that which will be used in the Wide Field/Planetary camera in NASA's Space Telescope, to be launched in 1985.

Caltech

he was on the Sergeant Program. (The Corporal and Sergeant were tactical missiles designed by JPL for the US Army. To this day a full-size replica of each stands outdoors in a rather out-of-the-way area of the Laboratory.) "After the launch of Sputnik 1," he said, "there was a strong mixture of euphoria and disappointment: euphoria because we knew that we, too, would be in the space business, disappointment because we weren't first." He went on to observe that Project Deal, which was managed by the late Dr. Jack Froelich, kept a rather low profile at the Laboratory. The official priority of the Vanguard Project plus the classified nature of many of Deal's ingredients accounted for the relative lack of visibility.

The Army team led by Wernher von Braun put together the first-stage Redstone booster at Huntsville while JPL provided the three upper stages and the payload containing Dr. James Van Allen's famed radiation-counter experiment. The JPL hardware was spin-stabilised at the very high rate of 750 rpm, and the stages were powered by scaled versions of the solid motor used on the Sergeant missile.

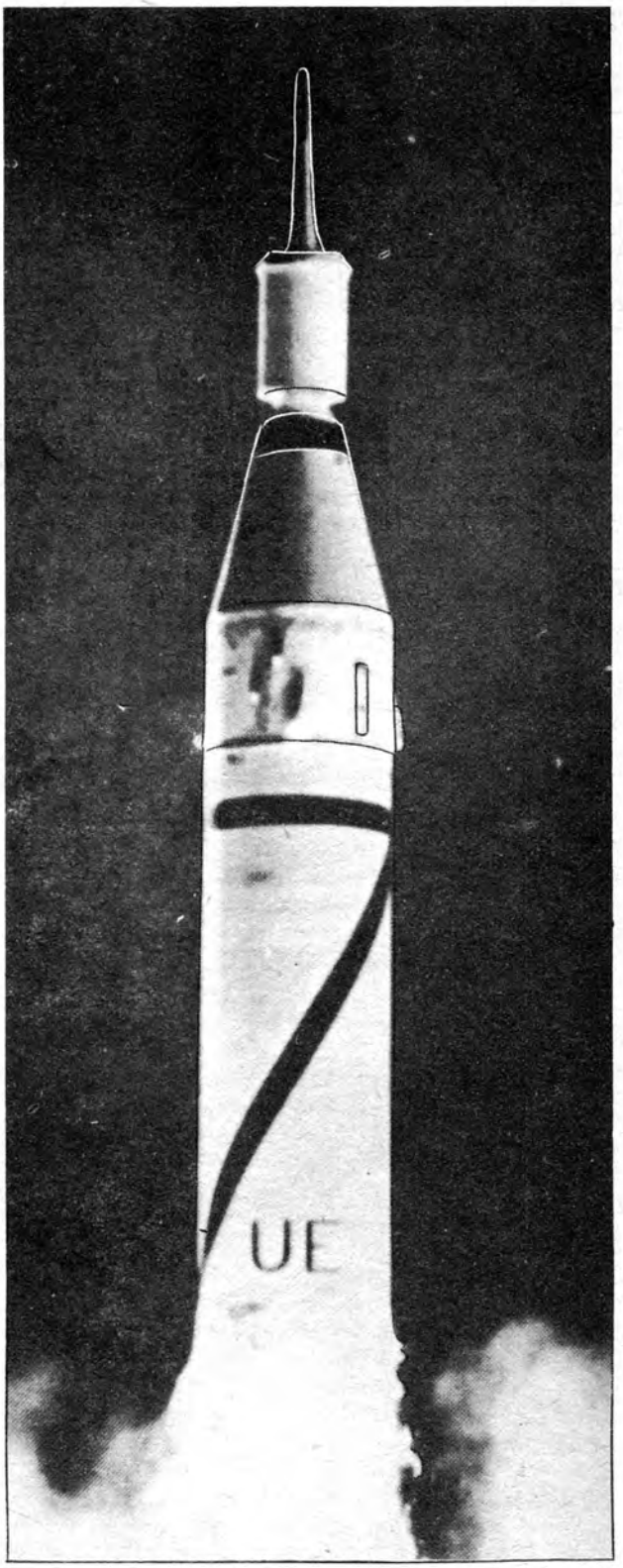
"Exciting and delightful" was the way Burke described Explorer 1 in orbit. Later that year JPL was transferred from the Army to NASA, which placed the Laboratory in a period of "rapid, evolutionary change" in Burke's words, as the switch from missiles to space probes was being completed.

Jim Burke gave me the names of about a dozen people to whom I must talk if I were to learn more about Project Deal. Among those still present at Caltech and JPL, I began with Walt Downhower and Al Hibbs.

Walter Downhower first worked at JPL in the summer of 1954, when he was still a student, and then joined the permanent staff in 1955. Currently he is the manager of strategic planning and analysis on the staff of Associate Laboratory Director Robert Parks. Among his early assignments was structural engineering for the Re-entry Test Vehicle (RTV) which was being used to test a dimensionally-scaled heat shield for the Army's Jupiter IRBM. Experience gained on RTV and Sergeant formed much of the basis for the quick response that was possible when JPL and the Army were unleashed to put Explorer 1 into orbit.

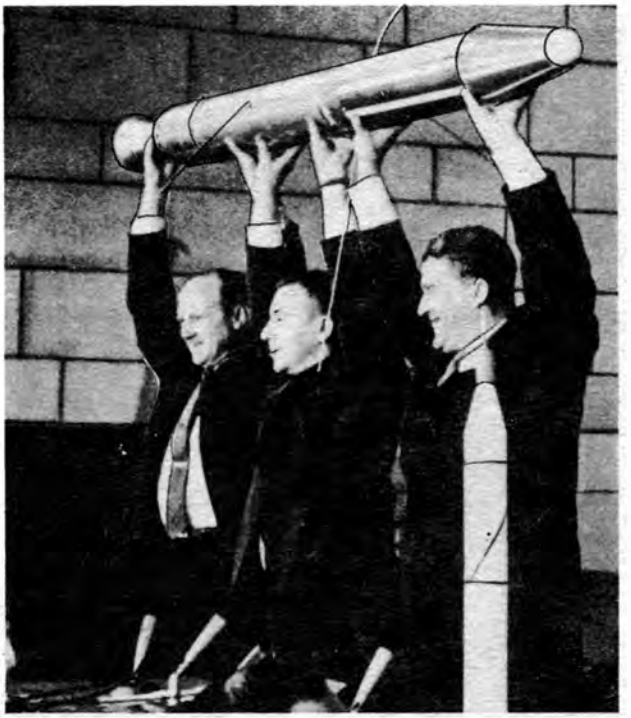
Downhower said that alignment and balance of the three spinning stages was a critical problem, and engineering techniques and controls had to be developed to prevent individual tolerances and clearances from accumulating to the detriment of the whole structure; at 750 rpm and with individual rocket motors burning to depletion in six seconds, errors would be swiftly and dramatically highlighted. Compatibility with the first-stage Redstone vehicle was facilitated by the shipping of the interface piece (called "the rotational launcher"), from Huntsville to JPL for final machining to match to the second stage.

When it came time to pick the scientific payload to be carried by Explorer, Dr. Henry Richter of JPL, who served as the International Geophysical Year scientific coordinator, went through the list of experiments for the Vanguard project with a view to selecting those "we could reasonably hope to incorporate in the short time which was available." Downhower added that it was presumed that the scientific merit of all the experiments was high, due to the prior IGY screening process. How fortunate that Van Allen's experiment was compatible with the high g loads and high spin environment produced by the satellite! Downhower said that for the only time in his life an aircraft was held for him while he and Richter rushed east to speak with Van Allen on the technical requirements necessary to incorporate his experi-



Launch of the Jupiter C (Juno 1) rocket carrying the Explorer 1 satellite. The spinning cylinder above the conical section carried the small solid-propellant motors of the second and third stages. The payload itself stood above the single motor of the fourth stage; both went into orbit. The launch date is usually quoted as the local-Cape time of 31 January; in GMT it was actually 1 February.

NASA



William Pickering, then director of JPL, celebrates with James van Allen and Wernher von Braun soon after hearing the news that Explorer 1 was safely in orbit.

NASA

ment into Explorer 1. Van Allen was out of town, but they spoke with one of his graduate students, George Ludwig (who later became science director at the Goddard Space Flight Center), and went on the next day to report the results to JPL director Dr. William Pickering who was in Washington, D.C. on one of his frequent visits to the capital.

In the rush and turmoil of the times Downhower recalled several out-of-the ordinary incidents in RTV and Project Deal. Once, a final check before launching downrange to the recovery spot in the ocean revealed a serious imbalance in the re-entry test payload. How this could have happened was a great mystery until Downhower found out that an extra quantity of shark repellant was sitting in the payload; it turned out that someone who should have known better saw that there was some "extra room" and had filled it with more repellant. Once the excess was compensated for, the payload balanced nicely and could tolerate the spinning environment. Another time at the Cape, unexplained pulses appeared in the data during the process of balancing the payload prior to launch. After checking and rechecking the equipment, Downhower happened to look behind the test facility and saw a railway track being repaired half a mile away. While he called out the strikes of the sledgehammer, a fellow engineer verified the simultaneous appearance of the data anomalies.

As mentioned previously, Project Deal was subject to security classification. When it was time to first balance the spinning upper stages a technical consultant who had no security clearance was summoned to JPL. His balancing sensors were installed by JPL personnel since he was not permitted to look at the vehicle, only at his equipment readout. Consequently a JPL man also had to visually observe the upper stages and call out the status of the strobing-process (a technique rather similar to using strobe lights on today's record decks for ensuring the correct spin). "He never saw what he balanced," Downhower said, "I've often wondered if, after the launch was announced, he figured out that he had been working on Explorer 1."

Dr. Albert Hibbs began at JPL in 1950 and like Walter Downhower carried out early work on spin dynamics. He was, in fact, the one who reported the visual results of the above-mentioned strobe analysis. A second area of specialisation was his early development of orbit-determination techniques.

Today, Al Hibbs is one of the best-known people at JPL and has been called "The Voice of Voyager" because of his reporting of that project's progress over television and radio. He is on the staff of Assistant Laboratory Director Donald Rea.

The big question immediately after the launch of Explorer 1 was, of course, had the satellite been placed successfully into orbit? Prior to its acquisition by a ground station, the only available information was some doppler measurements from the launch site, the observed time of the vehicle's disappearance over the horizon, and telemetry from the Redstone's guidance unit (the three JPL upper stages relied on the booster's guidance). Hibbs said that at the time of Explorer 1 he did not use an electronic computer to process these data but instead used graphical methods, such as "nomograms". Hibbs was able to inform General Medaris, who was holding a press conference at Patrick Air Force Base, that the satellite was in orbit and would remain up for about 10 years (a remarkably accurate prediction considering how little was known at the time about the atmospheric-density profile and dynamics; Explorer 1 re-entered after 12 years).

The first confirmation of this prediction took place when the Microlock station at Earthquake Valley in California picked up transmissions from Explorer. Hibbs, who was on the stage with Medaris at the press conference, had arranged with a colleague standing by a 'phone at the back of the auditorium to signal this success.

The orbit of Explorer 1 was not exactly as planned, and it arrived a few minutes late at the Earthquake Valley station. Laboratory Director Pickering was at the National Academy of Sciences in Washington, D.C. during the launch and had to suffer through the extra delay without the benefit of Hibbs' prediction. When someone said to him, "I guess you didn't make it this time, Bill," he replied, "I'll wait till my boys tell me that."

Hibbs also performed the trajectory analysis for Explorer 2, which failed to achieve orbit. Caltech physicist Dr. Richard Feynman, who later shared the 1965 Nobel Prize in physics for his work in quantum electrodynamics, was on hand for this second launch and came prepared with his own orbit-determination methods to challenge the speed of the electronic computer now being used. Feynman won. Everyone agreed that the satellite had failed to achieve orbit. However, just as Hibbs was preparing to leave and begin a holiday in Las Vegas, word came in that an amateur radio operator in Colorado had reported receiving signals from Explorer 2 in orbit! Hibbs checked and rechecked his calculations for six hours until he was absolutely certain of his results; and indeed while talking with him, I thought I detected a faint touch of annoyance directed toward that radio operator even after a quarter of a century.

RESCUE FROM ORBIT

By Gerald L. Borrowman

The frequent use of the Space Shuttle raises the possibility of astronauts being stranded in orbit should something go wrong with their craft. Present rescue plans involve a second Shuttle Orbiter flying to recover the stricken astronauts – a lengthy process if another Orbiter is not immediately available. An alternative is to return the crew using reentry capsules based on proven satellite designs up to 20 years old.

Reentry capsules from the Discoverer photo-reconnaissance satellites of the late 1950s and early 1960s pioneered the return of cargo safely from orbit. Since then, of course, the technique has been widely used, from manned flights to capsules with lunar samples.

Introduction

A Manned Escape System (MES) could be a scaled-up satellite reentry vehicle with provisions for a human payload and autonomous deorbit capability. Accommodations for humans would include attitude control for retrofire and impact attenuation during landing. Life support would be provided by pressure suits and not by the capsule itself.

The capsule would be equipped with contour couches, an ingress hatch, power supply and communications equipment. Up to four crew members could be seated around a central console. This arrangement permits compact seating without the need to fold back equipment for ingress and it allows semi-prone positioning for good acceleration tolerance.

An ablative heat shield would be attached to the conical portion of the reentry vehicle's forebody. The basic structure of the vehicle would be two nested semi-monocoque aluminium shells of conventional fabrication connected through an aft bulkhead.

The attitude control system would not be dependent on the crew since they might be incapacitated or unqualified to fly the craft. Thus a fully automated three axis attitude control system using infrared horizon sensors and rate gyros would be provided. It would automatically stabilize and position the vehicle for retro fire.

Retro fire could be controlled by the crew or from a ground station when the tracking network was in the best position to determine the proper timing for touchdown.

A deorbit module would contain all the attitude sensing components, the retro rocket, tankage, plumbing and other items associated with the fuel and oxidizer supply.

A retardation system would consist of single or multiple parachutes with associated drogue, reefing and deployment devices. The shock of a land recovery would be reduced by an inflated bumper deployed just before touchdown.

An Advanced Vehicle Recovery system with a gliding parachute could make corrections to the flight path of 25 miles or more in calm air or moderate the effect of prevailing wind conditions. It would also allow the crew to avoid obstacles.

MES Operation Modes

The basic Manned Escape System could be used in a variety of ways. In the "Ground Standby/Launch on Demand" method the MES could be a ground-based unit mounted on its own booster, the Titan IIIB, along with an orbital rendezvous package. It would be maintained on continuous standby for prompt launch when required. The upper stage/MES would manoeuvre to and rendezvous with the crippled craft. This mode could replace the present Space Shuttle rescue method in which another Shuttle is used as the rescue craft.

The major drawback of the "Launch on Demand" system is that even under the best conditions there would be an appreciable delay before the arrival of the rescue package to help the astronauts. This could be overcome by maintaining rescue packages in selected parking orbits. They would consist of a basic escape vehicle/s mounted on a bus module to provide limited orbital transfer, rendezvous, manoeuvre and docking capability, plus pointing for retro fire.

Again, there is a drawback with this method. The rescue module could be considerably displaced along the orbital track, although at the same basic inclination as the stricken vehicle. An appreciable time lag could therefore occur before rendezvous.

The "life boat" method of operating a rescue package offers the most readily available system at an economical cost. In this mode the escape system is integrally mounted on the manned system, such as the Orbiter or a Space Operations Center, from the outset. A four-man escape system could be installed in the Shuttle Orbiter with direct access by way of the airlock and egress tunnel. The actual mounting interface between the escape package and the Space Operations Center is envisaged as similar to a docking port with the capability for repeated separation and reattachment of replacement escape vehicles.

The reentering escape package would remain within ±50 miles along the ground track and ±10 miles cross range. This allows for selective choice of landing sites with a degree of freedom limited only by the time in orbit before retro fire.

Conclusions

The intensive manned orbital activities planned for the Shuttle and post-Shuttle eras emphasise a growing need for an orbital escape system. Fortunately, a basic escape vehicle can draw heavily on a wealth of experience accumulated over almost 20 years of unmanned satellite recoveries.

THE NASA GEODYNAMICS PROGRAM

By Clive Simpson

Introduction

The NASA Geodynamics Program is designed to find out more about the planet we live on, particularly in relation to the long-term crustal processes. Another important aim is the establishment of new geodynamics measurement services for precise position determination.

Achieving these objectives depends largely on the development, demonstration and use of techniques for measuring crustal motion and deformation. Also included in the programme is the measurement of the Earth's gravitational and magnetic fields.

In 1980 an agreement was signed between NASA, the US Geological Survey, the National Science Foundation, the Defense Mapping Agency and the National Geodetic Survey, to establish a coordinated Federal programme for the application of space technology to geodynamics.

The Techniques

The principal space techniques currently available for precise measurement of crustal motion and deformation, polar motion and Earth rotation are very long baseline interferometry (VLBI) and laser ranging (either to the Moon or man-made satellites).

VLBI uses two widely separated radio telescopes to pick up natural radio signals from an extragalactic source, such as a quasar. The difference in arrival times of identical signals at the two stations can be used to calculate the precise distance between the two telescopes.

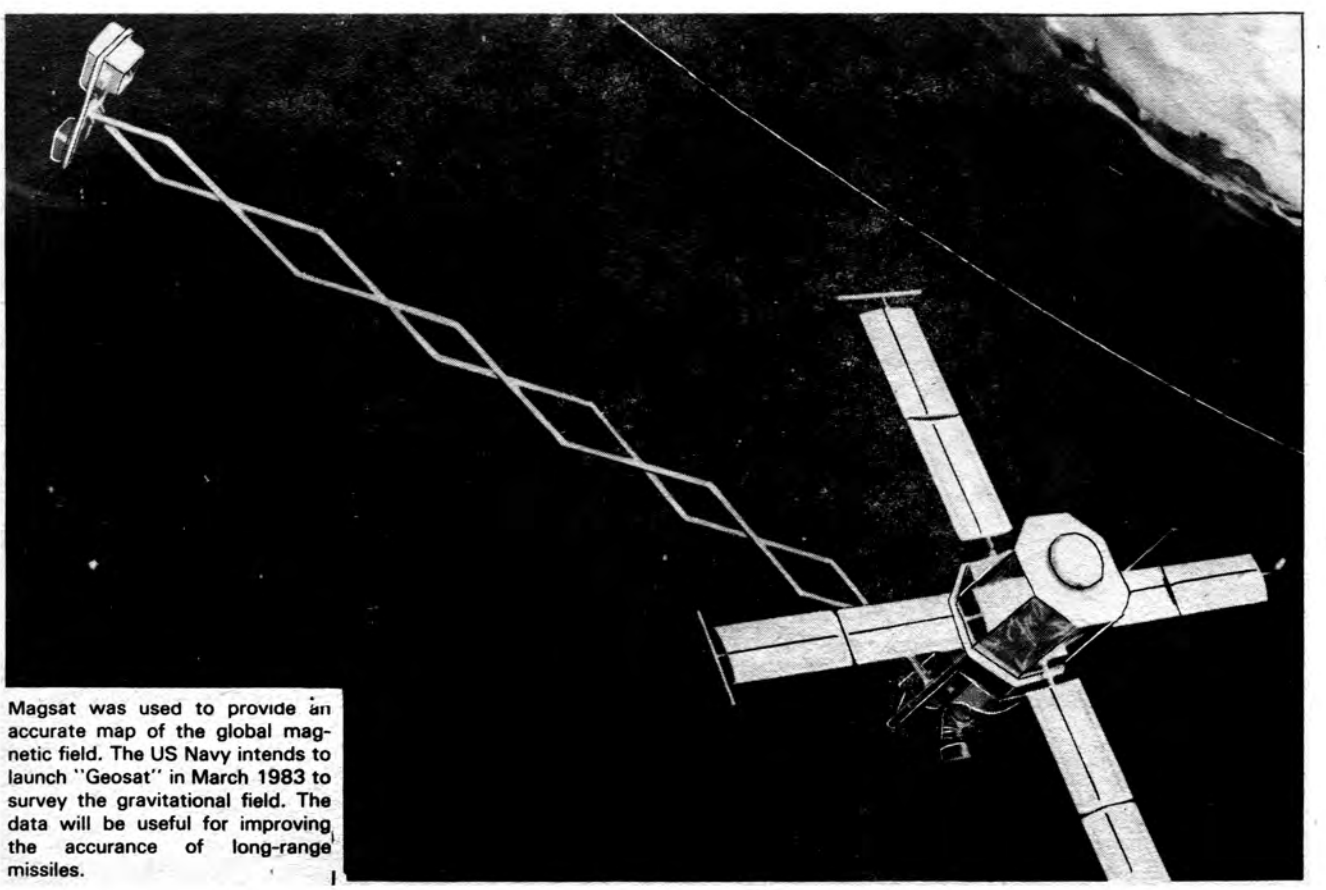
In laser ranging, beams are fired at artificial satellites or stations on the Moon. Once the distances between the two (or more) ground stations and the satellite are known, the distance between the ground stations can be calculated (see "Satellites and the Shifting Earth," p. 78, *Space Education*, December 1981).

NASA's Geodynamics Program, which received funding of $26.9 million in the last fiscal year, is divided into various elements: the Crustal Dynamics Project; Laser Network Operations; Research and Technique Development (RTD); Magnetic Field Satellite (Magsat); and the Earth Gravity Survey Mission (Gravsat).

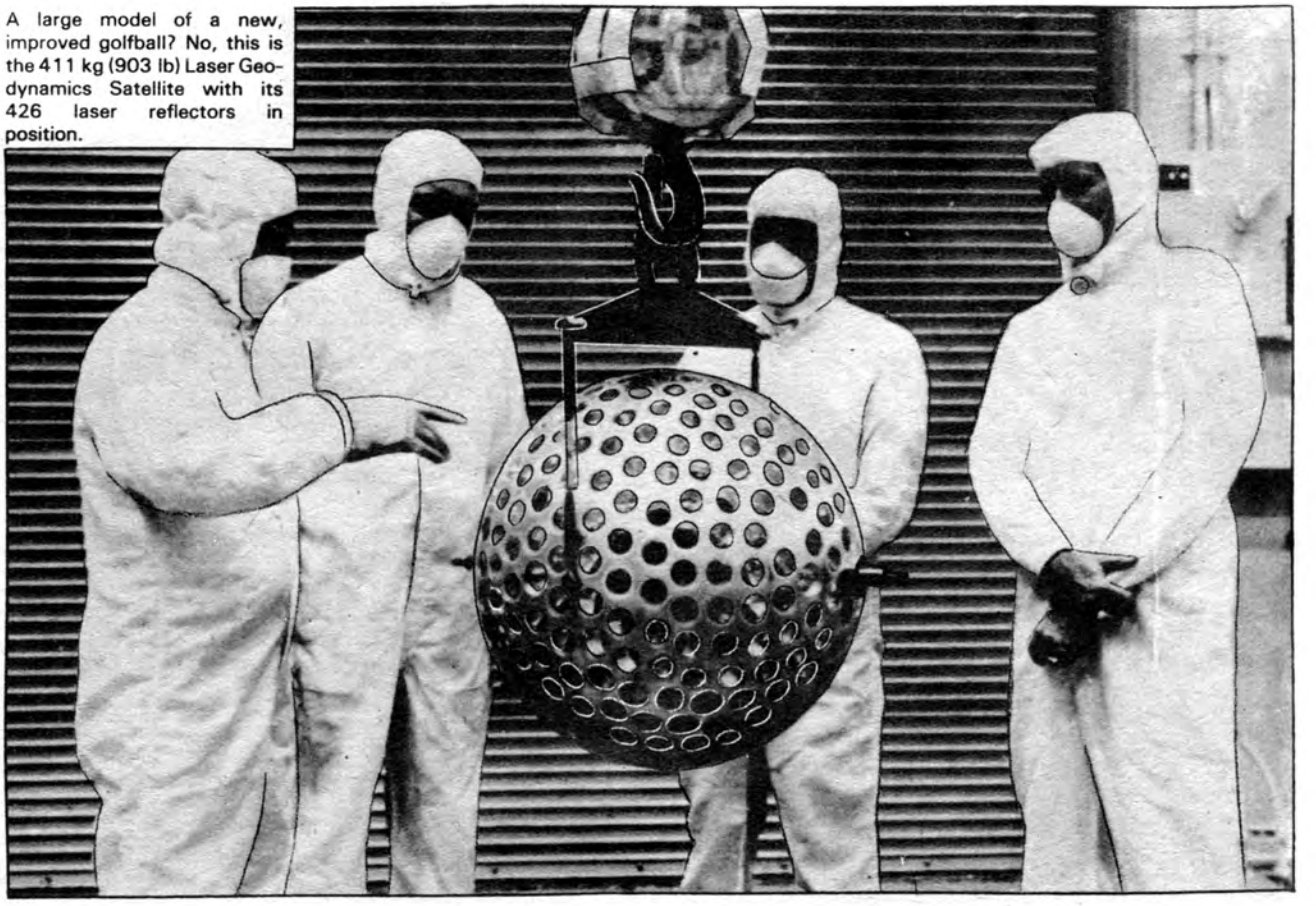
The Crustal Dynamics Project was born from a combination of several smaller projects. Among its objectives are the measurement and modelling of the following: regional deformation and strain changes related to Earthquakes at the plate boundary in the western United States and Alaska; the present relative velocity of major plates, with emphasis on the North American and Pacific plates; internal deformation of these; and regional deformation in areas where the tectonic setting is similar to that of Western US and Alaska.

Supporting this project is the NASA satellite laser network, consisting of eight mobile lasers operated by the Goddard Space Flight Center and four fixed lasers of the Smithsonian Astrophysical Observatory.

The magnetic field satellite (Magsat) decayed from orbit on 11 June 1980 after almost eight months of collecting data to



Magsat was used to provide an accurate map of the global magnetic field. The US Navy intends to launch "Geosat" in March 1983 to survey the gravitational field. The data will be useful for improving the accurance of long-range missiles.



A large model of a new, improved golfball? No, this is the 411 kg (903 lb) Laser Geodynamics Satellite with its 426 laser reflectors in position.

update and refine world and regional magnetic charts and maps, and for the compilation of global crustal magnetic anomaly maps. Magsat provided the most accurate measurements of the global field ever obtained and the first measurements of the vector field in low Earth orbit.

Requirements for some kind of gravity field mission were studied in 1979 and the following year a Gravsat User Working Group (GUWG) was formed by NASA to continue the work and assess the feasibility of an orbital mission. It will use satellite-to-satellite tracking between two low altitude drag-free satellites in polar orbit, and a two-way coherent Doppler system will be used to achieve tracking accuracies of one micrometre per second.

Under the Geodynamics Research and Technique Development (RTD) programme there are five main areas of research. The first element is global Earth structure and dynamics, designed to improve our understanding of the Earth's dynamics and global structure.

To date, one of the most significant results has come from the analysis of upper-air zonal wind data to compute the angular momentum of the atmosphere and the resulting changes in the length of day. Fluctuations in the length of day with a total amplitude of 0.35 milliseconds and a 55 day period have been detected.

It is also thought that the complex interaction of pressure, gravity and the magnetic field in the core may influence the Earth's dynamical motion.

The second element of RTD is known as regional crustal deformation modelling, under which studies will be conducted in various tectonic settings. Several themes characterise this work, one being the growing need for extension and refinement of the body of concepts that make up the plate tectonics hypothesis.

Lithospheric Structure and Evolution is the third area. This is aimed at obtaining a better understanding of the dynamical mechanisms that are presently active. Studies are being conducted in relation to the structure and evolution of the lithosphere with the objective of deriving plate-driving mechanisms, including mantle convection, to explain current plate motion measurements.

The fourth element of RTD is the development of gravity and magnetic field models under the heading of Geopotential Field Models. The gravitational field of the Central Pacific area has been mapped using satellite-to-satellite tracking between Geos 3 and ATS 6. Significant new anomalies appear on the map produced near the east Pacific rise, with a trend along the ridge direction and continuing through North America.

Finally, there is a section devoted to Advanced Geodynamics Instruments, involving studies to support the development of new methods for making geodynamics measurements using space systems and techniques.

Conclusions

In this brief outline it can be seen that the NASA Geodynamics Program is playing an important role in evolving the vital space techniques needed for such precise measurements as crustal motion. NASA is using and developing space technology with other agencies to help in establishing new or improved geodetic services. Over the next decade the programme will help to build up an increasingly detailed picture of the Earth's structure and the processes that shape it.

PHOTOGRAPHY OF ORBITING SATELLITES

By Joel W. Powell

Introduction

The feared loss of several heat protection tiles from the Space Shuttle on its maiden flight in April 1981 brought to light a remarkable capability of the US Air Force to photograph orbiting spacecraft from ground-based telescopic cameras. From two sites in the United States, the highly classified cameras, code named Teal Amber and Teal Blue, provide computer enhanced high resolution close-up photographs of Soviet and Chinese spacecraft for detailed intelligence examination.

Situated at Malabar in Florida and Mount Haleakala, Maui in Hawaii, the large telescopic cameras produce detailed images by computer enhancement techniques. The target object is raster scanned electronically, and successive scans are combined ("averaged" together) to produce the final high resolution image. A real-time television monitor would be part of the operation, as in the GEODSS tracking system (described later).

It has been reported that the system has been used to photograph cosmonauts during one of the EVAs conducted from the Soviet Salyut 6 space laboratory. There is no figure available on the system's resolution, but it may be less than 1 m, if the system could clearly resolve cosmonauts in space or examine the heat shield tiles of the Space Shuttle Orbiter.

As soon as the tile damage to *Columbia* was discovered, NASA was in contact with the Defense Department about using the cameras to attempt an examination of the critical under side tiles of the Orbiter. In an interview, Flight Director Eugene Kranz revealed that two attempts to photograph *Columbia* were made from the facility at Malabar in Florida. An attempt on revolution 17 failed because the spacecraft was too close to the horizon, and on revolution 21 clouds obscured the Florida skies.

Kranz was asked if there were sites other than in Hawaii and Florida, and he replied that that was "classified" [1]. *Columbia's* cargo bay was facing the Earth at those times as well [2]. Revealing the existence of the cameras was awkward for the Defense Department because the system was almost unknown prior to the Shuttle launch [3].

It is not known if there are more than two observation sites, but other monitoring and tracking networks have at least three locations (is it possible there was a site in Iran?). By way of example, the new DoD network for detecting and tracking orbiting spacecraft, GEODSS (Ground-based Electro-Optical Deep Space Surveillance), has five stations. Situated at White Sands in New Mexico, near Taegu in South Korea, Diego Garcia in the Indian Ocean, Mount Haleakala at Maui (with the Teal Blue site) and Portugal (provisonal) [4], each GEODSS facility uses two 101 cm (40 in.) telescopes to track statellites as small as a football at the distance of the geostationary orbit [5].

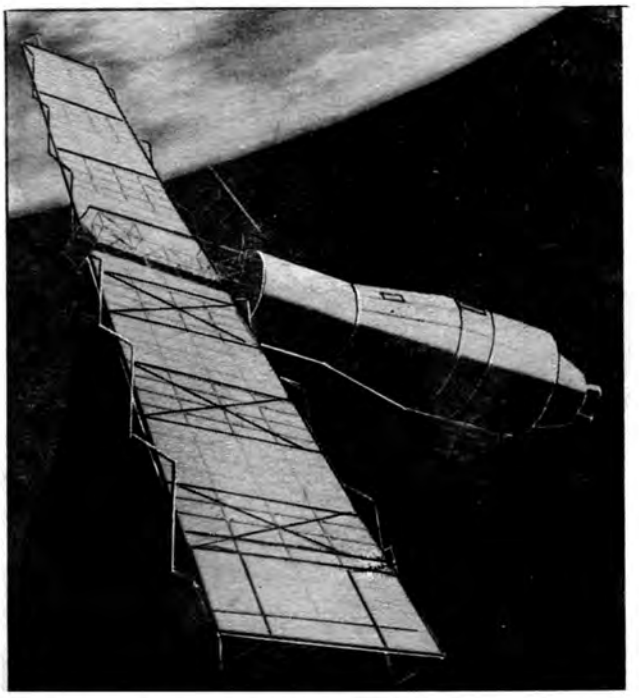
Gene Kranz offered no comment when asked whether reconnaissance satellites were used to examine the Shuttle Orbiter [6]. Richard C. Hoagland writing in *Science Digest* [7] suggests that NASA was so confident that there was no tile damage after the telescopic cameras failed to photograph *Columbia* because a Big Bird reconnaissance satellite was used to photograph the tiles from space. Big Bird's very high reported ground resolution of about 15 cm (6 in.) would also enable it to examine a target in space.

Origin and Development

The concept of photographing orbiting satellites was a logical outgrowth of optical satellite tracking by Baker-Nunn cameras since the days of Sputnik. Theoretical optical calculations showed that a moderately sized telescope ought to be able to resolve an object several hundred kilometres out in space. The Earth's atmosphere was the limiting factor in the concept, causing blurring and fluctuation of the image. A tracking system sufficiently accurate to lock on and hold an orbiting object at close range was also a serious problem.

The damaged Skylab space station was a target for the Cloudcraft camera, confirming the damage done to the solar arrays and meteoroid shield.

NASA



The Pegasus 2 micrometeoroid detection satellite was photographed in amazing detail (see text below).

NASA

Smaller Air Force missile tracking cameras at Cape Canaveral first demonstrated the concept in 1957. A tracking camera there caught Sputnik 2 in orbit, revealing the hammerhead shape of the Sapwod core rocket [8].

A programme to develop the system was approved in 1960, and a design was completed in 1961. The location chosen was at Cloudcroft in New Mexico (altitude 2,762 - 9,061 ft.), near Holloman Air Force Base. Construction of facilities began in 1962. Designated the Electro-Optical Observation Site, the installation was run under the auspices of the Air Force Avionics Laboratory [9]. Head of the project was Edmund T. Tyson who set up the Air Force's first optical satellite tracking station in 1957 at Cloudcroft.

Facilities

The observatory used a 122 cm (48 in.) reflecting telescope with two 13 cm (5 in.) spotting scopes in separate domes. In addition to the usual azimuth and altitude mountings, the primary telescope was rotatable about its base. The dome slit retracted to a 180 degrees open position enabling a target to be tracked from horizon to horizon [10]. The spotting scopes were "slaved" to the primary through an IBM 1800 computer to provide precise tracking commands to the servo-system.

Tracking was achieved by visual and photographic means. A Leica 35 mm camera was mounted on the telescope, and made exposures of about 1/125 second on Kodak 4X black and white ultra high speed film. The performance of the system was amazing. Resolution was 1 second of arc with the Leica camera, which had an effective focal length of 39.4 m (2,000 in.).

Observers were able to see discoloration (from the engines firing) at the aft end of the Saturn upper stage comprising the Pegasus II satellite. It was possible to watch special tracking stripes on the sides of the MOL test payload (launched in November 1966) "gradually grey out in about two weeks due to ultra violet erosion of the paint." Edmund Tyson stated that the telescope could resolve the Echo II balloon as a dot as far away as the Moon.

After the start of observations at Cloudcroft in 1964, the Advanced Research Projects Agency commissioned the construction of the Mount Haleakala site in Hawaii, run under contract by the University of Michigan [11]. Today, the Cloudcroft installation has been taken over by the Sacremento Peak Observatory and is no longer used for satellite tracking. Astronomical photoelectric photometry is now conducted there with a contract from the Air Force Geophysics Laboratory. Tracking was apparently phased out in the mid-1970's, transferred to the other sites of the network.

Conclusion

As the 1980's progress, the electro-optical imaging of Soviet and Chinese military spacecraft will become increasingly important. Rumours of Soviet space laser tests, winged manned spacecraft and anti-satellite battle stations can be verified by closeup pictures, such as the report that the Cosmos 1267 vehicle, that docked to Salyut 6 in June 1981, carried launching tubes for 1 m diameter anti-satellite "torpedoes" [12]. Such an identification, though doubted by some sources, would have been made with Teal Amber and Teal Blue.

Another use of the system may be direct observation of on-orbit tests of the new American Asat weapon, which is launched from an F-15 fighter aircraft. As with the Space Shuttle, closeup examination of other American spacecraft is possible when trouble arises or if there is an anti-satellite attack. It would not be unreasonable to assume that the Soviets also possess a similar capability.

The electro-optical imaging system pioneered at the Cloudcroft Observatory combines high precision pointing and electronic scanning and enhancement to provide one of the most valuable intelligence tools in the study of the Soviet military space programme today.

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SATELLITE DIGEST – 161

Robert D. Christy

Continued from the January issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

TELESAT 5 1982-82A, 13431

Launched: 26 Aug 1982 from Eastern Space and Missile Center.
Spacecraft data: Cylindrical construction based on the Hughes HS 376 standard satellite body, length 6.7 m, diameter approx. 2 m and mass around 1200 kg.
Mission: Canadian domestic communications satellite.
Orbit: Geostationary, located above 104 deg west longitude.

MOLNIYA-3(19) 1982-83A, 13432

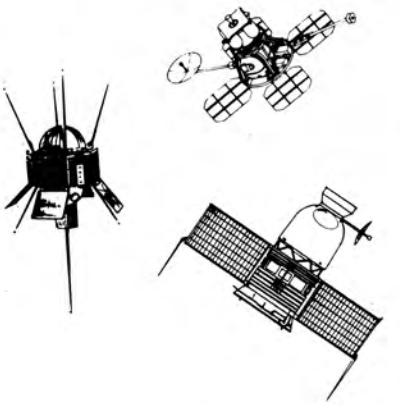
Launched: 0010, 27 Aug 1982 from Plesetsk by A-2-e.
Spacecraft data: Cylindrical body housing instrumentation and the payload is surmounted by a conical motor section. Power is provided by a "windmill" of six solar panels. Length is about 4 m, diameter 1.6 m and the mass around 2000 kg.
Mission: The satellite provides telephone and telegraphic communications and transmits Central Television programmes to "Orbita" ground stations in the USSR and other countries.
Orbit: Initially a low parking orbit and then injected into a highly elliptical orbit of 457 × 40,823 km, 736.60 min, 62.87 deg. Later manoeuvred to approx. 450 × 39,500 km, 718 min to ensure daily repetition of ground tracks.

COSMOS 1402 1982-84A, 13441

Launched: 1005, 1 Sep 1982 from Tyuratam by F-1.
Spacecraft data: Not available but probably several tonnes mass.
Mission: Military reconnaissance using radar.
Orbit: Initially 251 × 264 km, 89.65 min, 65.00 deg and maintained constantly near that height by the use of a low thrust motor.

COSMOS 1403 1982-85A, 13448

Launched: 0910, 1 Sep 1982 from Tyuratam by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument unit, and a cylindrical, supplementary payload at the forward end. Length about 6 m, diameter (max) 2.4 m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 354 × 416 km, 92.26 min, 70.38 deg.



COSMOS 1404 1982-86A, 13449

Launched: 1150, 1 Sep 1982 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1403.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 358 × 414 km, 92.30 min, 72.85 deg, manoeuvrable.

KIKU 4 1982-87A, 13492

Launched: 3 Sep 1982 from Tanegashima Space Centre by N-1.
Spacecraft data: Box-shaped body with solar panels, 0.85 × 0.85 × 2.1 m deep and with 6 m span. The satellite is 3 axis stabilised using reaction wheels. The mass is 385 kg.
Mission: A series of technical experiments connected with operation of the satellite itself and the development of future spacecraft systems. Of particular interest are the attitude control system, the deployment and operation of the solar array, and the efficiency of the thermal control system. The experiments package includes a vidicon camera for Earth images, an ion engine, an active thermal control system and a magnetic attitude control system.
Orbit: 965 × 1228 km, 107.10 min, 44.62 deg.

COSMOS 1405 1982-88A, 13508

Launched: 1745, 4 Sep 1982 from Tyuratam by F-1.
Spacecraft data: Not available but probably several tonnes mass.
Mission: Probably an ocean surveillance satellite carrying out electronic reconnaissance.
Orbit: 430 × 444 km, 93.30 min, 65.02 deg.

COSMOS 1406 1982-89A, 13519

Launched: 1020, 8 Sep 1982 from Plesetsk, possibly by F vehicle.
Spacecraft data: As Cosmos 1403.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package, recovered after 13 days.
Orbit: 212 × 220 km, 88.81 min, 82.30 deg.

CHINA 10 1982-90A, 13521

Launched: 0730, 9 Sep 1982 from Shuang Cheng Tse by Long March 2.
Spacecraft data: Not available.
Mission: Satellite development, including recovery techniques. Part of the satellite was recovered after 4 days.
Orbit: 175 × 384 km, 90.08 min, 62.98 deg.

COSMOS 1407 1982-91A, 13546

Launched: 1530, 15 Sep 1982 from Plesetsk by A-2.
Spacecraft data: Possibly similar to Cosmos 1403.
Mission: Military photo-reconnaissance, recovered or re-entered after 31 days.
Orbit: 174 × 340 km, 89.64 min, 67.15 deg.

COSMOS 1408 1982-92A, 13552

Launched: 0505, 16 Sep 1982 from Plesetsk by F vehicle.
Spacecraft data: Not available.
Mission: Electronic reconnaissance.
Orbit: 635 × 669 km, 97.78 min, 82.57 deg.

EKRAN 9 1982-93A, 13554

Launched: 1845, 16 Sep 1982 from Tyuratam by D-1-E + apogee motor.
Spacecraft data: A cylinder with a pair of boom-mounted solar panels and a transmitting array. Length 5 m, diameter 2 m and mass around 2000 kg.
Mission: To transmit programmes of Central Television to collective receiving stations in remote areas.
Orbit: Initially a low parking orbit at 51.6 deg inclination, then transferred to an elliptical orbit at 47 deg inclination, followed by circularisation into a geostationary drift orbit before stabilisation above 99 deg east longitude (Statsionar T).

ASTRONOMICAL NEWS

By Prof. John S. Griffith*

COMETS AND THE EARTH

A recent theory contends that, through sporadic bombardment of the Earth by captured interstellar bodies, there is an overall "galactic control" of terrestial phenomena. Conversely, this implies that phenomena we see here on Earth may provide information about the past history of the Galaxy.

The theory starts with comets, created in galactic spiral arms, being sporadically captured as the Sun moves through the arms. These capture events periodically replenish the Oort comet cloud and the Apollo asteroid populations and, in turn, lead to episodes of Earth bombardment.

Bombardment may lead to triggering of plate tectonic phenomena, ice ages, geomagnetic reversals, etc. These geophysical consequences are discussed by S. V. M. Clube and W. M. Napier of the Royal Observatory, Edinburgh, in a paper to appear in *Earth and Planetary Science Letters* entitled "The rôle of episodic bombardment in geophysics."

Here I concentrate on the astronomical aspects of the theory (reported in a paper "Spiral Arms, Comets and Terrestial Catastrophism" to be found in the *Quarterly Journal of the Royal Astronomical Society*, **23**, pp.45–66, 1982).

Various other authors have proposed catastrophy theories based solely on geochemical data. For instance, the impact of a Solar System meteorite from the Apollo population was supposed to have released dust into the stratosphere, thus impeding photosynthesis and leading to the collapse of the food chain and the extinction of the dinosaur. Cometary impacts have been supposed to lead to cyanide poisoning, while passage through a dense interstellar cloud would supposedly lead to hydrogen poisoning, with the captured interstellar dust causing the onset of ice ages.

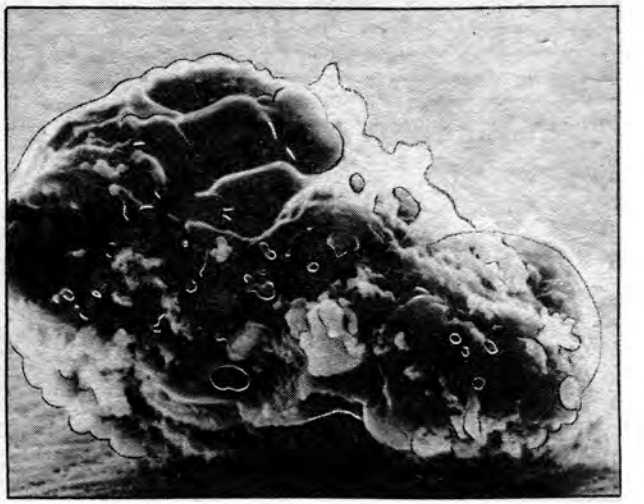
It is known that the Earth-crossing Apollo asteroid populations will last for only around 30 million years, needing constant replenishment, perhaps from the remnants of comets. These in turn, come from the Oort cloud of 10^{11} comets at a mean distance of 100,000 AU. This cloud needs, itself, to be disturbed to provide sufficient replacement material. The Oort cloud is shown to be unstable and hence to need replenishment from the interstellar sources. There are also some 90 crypto-explosion craters on the Earth that may have resulted from cometary impact.

LIFE IN THE UNIVERSE

In the June 1982 issue of the *Quarterly Journal of the Royal Astronomical Society*, David G. Stephenson of the Max Planck Institüt für Aeronomie discusses models of interstellar exploration, the Search for Extraterrestial Intelligence, and the probability of life elsewhere in the universe.

Stephenson starts by describing the exponential expansion model of interstellar exploration, in which each interstellar vessel generates several new vessels at every planetary system visited, leading to complete exploration of our Galaxy in a few tens of millions of years. From this model, as there are no obvious signs of our Solar System having been visited, the conclusion was drawn that we are the only technically able intelligent species in this Galaxy.

However, there are, as Stephenson points out, objections and modifications to this model. For example, contact may be made only at the outer edges of planetary systems, and we have not yet advanced sufficiently to be able to see whether



Studies of material from comets may shed light on the formation of the Solar System 4,500 million years ago. This particle was collected by an aircraft flying high in the atmosphere.

NASA

there is evidence of contact in the Oort cometary cloud.

An extension of the exponential expansion model is that of automated probes, capable of self reproduction from materials to be found in planetary systems. Perhaps the asteroids represent the waste from such a visit, where light elements have been taken as fuel for a generation of probes. Perhaps the probes themselves are capable of evolution (as a safeguard against breakdown and deterioration) and eventually adapt to survival in interstellar space.

Stephenson draws attention to the type of civilization that would initiate the launch of the probes. It needs a stable social system contemplating no return from its investment in interstellar missions for many thousands of years, and in order to produce self-replicating probes must have the technical ability to construct all the material needs of its members from raw undifferentiated matter.

As a consequence the only return to be expected from the exploration is the harvest of knowledge – a harvest that can be transported easily by electromagnetic signals.

The probes would satisfy the exponential expansion model if:

(i) all systems are similar, do not need more than one visit, and are not affected by that visit;
(ii) only a small part of the total information content of the system is of interest;
(iii) all systems are destroyed or totally deprived of their independence as information sources by the visit of the probe.

Stephenson points out that the first condition implies that there is no use in sending out the probes. Given either the other two conditions, then an optimised model of the probe propagation involves using stars as raw material for probes. But this leads to total destruction of the Galaxy. Indeed making probes into independent intelligent beings leads to possible destruction of the parent planet.

If probes are made simpler, using only some portions of a planetary system, then we may have been visited once – possibly in the distant past – and no longer have optimally placed material for future probes.

It has been suggested that a reason for no visits is that the

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Earth is a form of galactic zoo or nature reserve – or a region that is not disturbed by information-gathering probes. Using exponential expansion models is like strip mining, where no regard is paid to the effect of the exploiter's activity on the original system. Stephenson points out that only when we approach the level of an extraterrestial civilization is the yield of information greater by mutual exchange than by observation.

Stephenson claims that the idea that we are alone as intelligent beings is not supported by the absence of any recognisably alien artifacts in the Solar System. Only the pursuit of information as a source of wealth seems valid to describe to highly intelligent, well-experienced beings. Our value has left us undisturbed. We should not expect to be contacted until we can be regarded as a junior partner. However, *unintended* emissions from distant advanced cultures may be detected and should continue to be searched for.

ANTIMATTER PROPULSION

Dr. Robert L. Forward of the Hughes Research Laboratories has recently put forward a detailed proposal for interplanetary and interstellar travel using antimatter as energy source (Hughes Research Report 549, "Antimatter Propulsion").

Forward notes that the antiproton/proton reaction is more suitable for propulsion than the electron/positron reaction. He notes that a small amount of antimatter should be used to heat and expel a much larger amount of propellant. For example a one-ton payload to Alpha Centauri at 10% the speed of light requires four tons of liquid hydrogen and 9 kg of antimatter.

Where does the antimatter come from and how is it stored? The accelerator at CERN in Switzerland has already generated antiprotons and stored them in a magnetic "raceway" storage ring for over four days. Forward examines in detail additional proposals and finds there are acceptable techniques available using high current, high voltage particle accelerators to produce antimatter (similar to those being developed for use in fusion research) with storage using magnetic fields, electrostatic levitation or laser levitation.

Even if we cannot obtain interstellar flight, antimatter propulsion would revolutionise transportation in the Solar System. He ends by stating, "With all the possibilities, certainly the question is no longer: "Can we go to the stars"; it is "When do we go to the stars?"!

PLANETS OF STARS

The stars Lalande 21185 and BD+ 5°1668 are located close to the Sun, being respectively 2.5 and 3.75 parsecs away. For over 40 years, observations have been made of their positions using the 61 cm telescope at the Sproul Observatory (Swarthmore College, Pennsylvania). These observations are part of the Sproul Program of astrometric surveillance started by Peter van de Kamp in an attempt to discover objects of planetary sizes orbiting around other parts.

John Hershey and Sarah Lee Lippincott, writing in the May 1982 *Astronomical Journal* (**87**, 840–844) report that, compared to the reference stars, the variations in positions of the two stars can mean that there are associated planetary mass objects.

For Lalande 21185, a main sequence M2V type star, a companion of at most 2 Jupiter masses is indicated, with an orbital period of about 22 years.

The M5 dwarf BD+ 5°1668 shows possible companion planets of the size of 1.1 Jupiter masses for a ten-year period, 0.7 Jupiter masses for 20 years and 0.4 Jupiter masses for 40 years.

It is pointed out that a system of planets around a star would cause a complicated displacement curve, but that over a long period of time the dominant masses would indeed become the most evident.

Certainly an object of several Jupiter masses, in the appropriate period, would be unmistakably detectable and visible in the observations of the nearest stars in the Sproul plate series.

SOLAR NEUTRINOS

Ever since the 15 year old discrepancy between observation and theory of the quantity of electron neutrinos from the nuclear reactions in the Sun was found, efforts have been made to resolve one of the most persistent problems in astrophysics, with little success.

B. W. Filippone of the Department of Physics, University of Chigago, and D. N. Schramm of the Enrico Ferini Institute in the *Astrophysical Journal*, **253**, pp. 393–398 (Feb 1982) point out that perhaps there are other types of neutrinos (muon or tau) produced which would not be detectable by the present apparatus.

Their discussion includes more recent results from theory which reduces the gap between theoretical calculations and observations. After some discussion, theory concludes that we may not know that the solar neutrino problem really exists until a new detection system using gallium has been shown to be capable of detecting more neutrinos. The new detection system was proposed by J. N. Bahcall and others in *Physical Review Letters*, **40**, 1978, p. 1351.

GRAVITATIONAL LENS QUASARS

Long before any actual discovery, it had been predicted theoretically that a galaxy lying between the Earth and a quasar could act as a gravitational lens, bending the light from the quasar around it. It has been known for over 60 years that light from the stars lying close to the Earth-Sun line is bent gravitationally by the mass of the Sun, but it was not until 1979 that the first convincing gravitational lens was reported by Walsh, Carswell and Weymann (*Nature* **279**, 381). William Keel of the Lick Observatory (*Astrophysical Journal*, **225**, 20–24 1982), investigated the nature of the light variations in the double quasar Q 0957+561. The first observations showed the two images to have great similarity in their optical spectra, and Keel notes that the variations in brightness imply a difference in the time delays of at least 2.7 years.

These light variations may either be due to changes in the properties of the lens (stars moving across the beam) or in the quasar itself. Because of the asymmetry and rapidity of the variations, stars moving across the beam are ruled out, leaving variations in the quasar itself which are within the ranges of variations in other quasars. Further observations, particular of variations in the (at the moment) constant brightness of one image, will confirm the hypothesis.

Another gravitational lens is reported on by D. W. Weedman of the Pennsylvania State University and R. J. Weymann, R. F. Green and T. M. Heckmann of the Steward Observatory (Arizona) in the *Astrophysical Journal Letters* **255**, L5–L9 (1982). Using the Canada-France-Hawaii 3.6 m telescope, it was evident that the spectra of each element of the pair were markedly similar. The authors note that now, of the over 1,000 quasars known, only three have the properties of a lensed quasar.

A LIMIT TO QUASARS

A search for emission-line quasars with red-shifts between 3.7 and 4.7 (corresponding to velocities 0.917 and 0.97 times the speed of light) indicates a significant decrease in space

density of quasars in the range. In fact, the redshift record now stands at 3.78 as noted in this months "Space Report" (quasar PKS 2000-330).

Patrick Osmer of the Cerro Tololo Inter-American Observatory, La Serena, Chile conducted the search using the CT10 4 m telescope (*Astrophysical Journal* **253**, pp. 28–37).

He notes that there must be a sharp decrease in the density of quasars around z=3.5, and that this redshift represents a time considerably later in the development of the Universe than that at which quasars were originally expected to have been formed. Indeed, with the interpretation of quasars as events in galactic nucleii, it is difficult to imagine galaxies existing very long before the quasar manifested itself. The redshift limit for quasars would have important consequences for our ideas of how and when galaxies formed. Osmer points out that quasars could exist at larger redshifts but be hidden behind some absorbing material. If the redshift limit is real, then we are observing quasars at their earliest stages; "Can the youngest galaxies be far behind?"

FUTURE OF THE UNIVERSE

Atomic nuclei are often considered to be made up of protons and neutrons. There is growing speculation that protons are unstable. Admittedly their lifetime is considered to be around 10^{30} years, but their decay would take place gradually with consequent release of energy. Assuming that protons decay in positrons, neutrinos and photons, workers in America have estimated the effects of proton decay on the future history of the universe.

Proton decay would release enough energy to keep white dwarf stars at a temperature of about 5K from 10^{17} to 10^{30} years. Similarly, neutron stars would be kept around 100K.

After about 10^{20} years, it is expected that galaxies will have largely "dissolved" because of collisions leading to material reaching escape velocity. As surface material evaporates, the centres condense, and between 90% and 99% of a galaxy evaporates. The Universe at 10^{30} years will consist mainly of dead stars, with 1% of the mass in the form of atomic hydrogen or helium. Large black holes from galactic nuclei will make up 9% of the mass, with the atomic matter constituting only about 1%.

After proton decay ceases, the energy released dominates the mass density of the Universe. Eventually, the energy density of the supermassive black holes take over, decaying after about 10^{96} years, leaving the Universe as a tenuous plasma of positrons and electrons.

For a closed cyclical Universe that bounces, the maximum radius (and lifetime) increases in each cycle, giving an enhanced probability for life in each subsequent cycle.

NON-HOLE IN BOOTES

Kirshner, Oemler, Schecter and Shechtman reported in *Astrophysical Journal Letters* **248**, L57 (1981) that a volume of 10^6 Mpc^3 was empty of galaxies: the void in Bootes. V. A. Balgano and D. W. Weedman of the Pennsylvania State University report in *Astrophysical Journal Letters* **255**, L1–L4 (1982) that the "void" is *not* empty. At least 12 Markarian galaxies are within the region, and their distribution in space is expected. The void appears to be filled.

SOCIETY SOUVENIRS

The Society produces a wide and varied range of items for sale, all of high quality. Why not buy a T-shirt or badge for yourself, or treat a friend? Remember, you'll not only support our Development Appeal but also provide valuable advertising for the Society.

T-shirts

Available in BLUE or WHITE with large BIS logo; chest sizes 32–34, 34–36, 38–40 and 42–44 in. Cost is £3.50 in the UK or £4.00 ($9.00) abroad, post free.

Sweatshirts

High quality BLUE sweatshirts with BIS logo. Chest sizes 32–34, 34–36 and 42–44 in. available. This is your last chance: our stock will not be replaced. Cost: £7 UK, £7.50 ($16.00) abroad, post free.

Badges

Three types of badges are available, all with the Society logo:

- **Enamel lapel badges (£1 UK, $3 abroad)**
- **Cloth blazer badges (£1 UK, $3 abroad)**
- **Metal car badge (£3 UK, $8 abroad)**

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A dark BLUE tie with the BIS logo visible just below the knot. Cost £6 UK, £6.50 ($15) abroad, post free.

Binders

The ideal way of keeping your magazines in perfect condition. *Spaceflight* binders carry *BLUE* covers, those for *JBIS* are *GREEN*. Gold lettering on the spine identifies the magazine, volume number and year. Cost: £5 ($11 abroad) each. Note: *JBIS* binder fit post-1976 volumes.

When ordering please be sure to specify exactly *what you require (size, colour, quantity etc). All orders to The British Interplanetary Society, 27/29 South Lambeth Rd, London SW8 1SZ, England.*

BOOK NOTICES

The Space Shuttle Operator's Manual
Kerry Mark Joels, Gregory P. Kennedy and David Larkin, Ballantyne, 1982, $9.95.

Aimed primarily at the adolescent space buff, this book will interest anyone who wants to know more about that wonderful flying machine, the Space Shuttle. It is jam-packed with facts, diagrams and tables. It is written as though it was indeed the Operator's (Pilot) Manual. Everything seems to be there at a first reading; from the standard flight plan to how to open the lockers; from how to get into your spacesuit to what to do in an emergency; how to use the "personal hygiene" systems to where the tiles fit on. It describes possible missions in occasionally minute-by-minute detail. There are several pages giving the launch sequence as though the reader were the crewman checking off the pre-flight checklist. There is a similar sequence for the landing. Everything seems to be described, even the standard program numbers for the various procedures in the flight-control computers.

This book is full of interesting incidental facts, too, eg why the Shuttle must orbit with its Cargo bay doors open (or it overheats); how only two space suits are carried so that if an emergency involving loss of cabin pressure occurs when the crew is more than two, the rest might climb into small (less than 1 m diameter) balls called "Personal Rescue Enclosures" which look like the alien in "Dark Star" and cannot be the best way to spend a few hours; how the human body in zero *g* relaxes naturally into a "neutral body position", which looks like a half crouching stand, so that the heels of any foot rests are built up to accommodate the foot-back raised posture; and so on.

Modelmakers will have a field day with this book. It seems to have detailed views of everything, and plans and elevations galore. There is even a foldout diagram of the flight deck instrumentation. You really begin to see yourself sitting there flying the thing.

Of course, it goes over the top at times. It is so enthusiastic it quotes the flight cost of $35/kg without mentioning that is the marginal cost, R&D costs having been "lost" in NASA's budgetting. There *are*, surprisingly, some gaps in the information. I searched in vain to find out where extra crew members will sit if more than four are carried.

On the whole, though, it is a must for those who are interested in the details of the space missions which grace their TV screens. This is a book to have handy on the shelf for reference, to swot up on at dead of night so that one can fly that machine in imagination at least. Just *in case* that dream can be turned to reality one day, you understand!

Extraterrestrials: Where Are They?
Eds. M. H. Hart and B. Zuckerman, Pergamon Press, 1982, 182pp, $22.50 ($9.50 paperback).

The question posed is that, after 10,000 million years and among hundreds of thousands of millions of stars, are we alone in our Galaxy?

Enrico Fermi is reputed to have asked the question "Where Are They?" at the dawn of the atomic age, having wondered why, after discovering and taming nuclear energy, advanced extraterrestrials were not in evidence here on Earth.

In this volume a number of leading experts contest the belief that other intelligent life is widespread in the Galaxy.

Advances in radio astronomy, the development of space exploration and the blossoming of molecular biology have all contributed to the widespread belief that life in the Cosmos is commonplace, a view supported at the more popular level by numerous reports of close encounters of various kinds, lavish SF movies and enormously saleable books on astronauts ancient and modern.

All of this has served to promote the idea that "they" are out there and either soon will be or already have been here.

During the past few years a new and more sobering input has been inserted into this picture. Space programmes, while highly successful, have clearly failed to produce evidence of extraterrestrial biology. The same applies to investigations with radio and optical telescopes.

An image of the Milky Way abounding in all kinds of advanced super-civilisations and bizarre life-forms is tremendously popular. But what if this is not so? The implications are both legion and fundamental.

This is a fascinating volume, reasonably argued, clearly printed, wholly factual in its approach and, perhaps for the first time, provides an attempt to evaluate the problem without bias and in a wholly rational manner.

The Peenemünde Raid
M. Middlebrook, Allen Lane, 265pp, 1982, £9.50.

During WW2, on the night of 17–18 August 1943, RAF Bomber Command launched an operation to destroy Peenemünde, then a secret research establishment located at a remote site in Germany. There, scientists and engineers were developing advanced forms of rocket projectiles to be used in large numbers to destroy London.

The secret raid prepared for this small target had some most unusual features e.g. a moonlight flight which could expose the bomber force to massive Germany fighter attack, the use of a Master Bomber to direct the operation, and a sophisticated plan for what turned out to be the only precision raid undertaken by the RAF by night during WW2.

In this volume the author describes not only the raid and its aftermath but also the work undertaken at Peenemünde, the lifestyle of the German community and of the many foreign workers there, Intelligence Information and, the fortunes of the British and Luftwaffe aircrews. He incorporates many of their personal memories into his narrative.

The Planet Venus
G. E. Hunt and P. Moore, Faber & Faber, 207pp, 1982, £10.

Venus, the nearest (at times) planet to Earth, is commonly regarded as the Earth's twin. Although it can be more brilliant than any other star or planet in the sky surprisingly little was known about it before the age of space probes. Some astronomers considered it to be a world covered with water, others had it as an extremely hot desert!

The problem was not resolved until Mariner 2 approached Venus in 1962. Since then, other space missions have examined the planet with the result that, coupled with radio and radar observations, maps can be drawn of the surface below its dense atmosphere.

The present volume is well written, extremely clear, and very interesting indeed. Those wishing to update their knowledge of Venus in handy form can hardly do better than refer to this volume. Besides a number of historical references, including a short chapter on its one-time "phantom" satellite, the book describes the instrumented probes which have examined the Venusian atmosphere and surface and concludes with chapters describing the results of these observations in detail.

Some of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

SPACEFLIGHT

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Continued from inside back cover

Lecture

Title: **SPACE OCEANOGRAPHY**
by Dr. J. O. Thomas
Imperial College, London

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **16 March 1983**, 7.00–9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Study Course

Title: **CATACLYSMIC VARIABLES**
by Dr. D. Jones
Royal Greenwich Observatory

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **30 March 1983**, 7.00–9.00 p.m.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of these Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

Study Course

Title: **THE NEW LA PALMA OBSERVATORY**
by Dr. P. J. Andres
Royal Greenwich Observatory

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **6 April 1983**, 7.00–9.00 p.m.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of these Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

Technical Forum

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **Friday, 3 June 1983**, 6.30–9.00 p.m., and **Saturday, 4 June 1983**, 10.00 a.m. to 12 noon and 1.30–3.30 p.m.

Topic: **THE SOVIET SPACE PROGRAMME**

It is anticipated that papers will be given at the Friday evening and Saturday afternoon sessions, with some Soviet space films being shown during the Saturday morning session.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society. Members with a special interest in the Soviet space programme are invited to attend. A registration fee of £3.00 is payable. Forms are available from the Executive Secretary on request, enclosing a stamped addressed envelope.

18th European Space Symposium

Theme: **FUTURE SPACE PROGRAMMES FOR EUROPE**

To be held in the Society's Conference Room at 27/29 South Lambeth Road, London, SW8 1SZ on **8–10 June 1983.** Organised by the BIS and co-sponsored by the DGLR, AAAS, AIDAA and AAS, with support from Eurospace. The number of participants will be limited to a maximum of 60, with priority to Speakers, Society Representatives and subject specialists.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society.

Programmes and Registration forms will be available in due course.

LIBRARY

The Library will be open to members from 5.30-7.00 p.m. on each of the following dates:

26 Jan. 1983	2 Feb. 1983
16 Feb. 1983	2 Mar. 1983
16 Mar. 1983	30 Mar. 1983
6 Apr. 1983	

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

GIFTS AND DONATIONS TO THE SOCIETY

Most established learned bodies in the UK owe their prestige and affluence to Endowments and Gifts conferred in the past. These have enabled them to perform tasks, expand, build up valuable libraries and collections of paintings, seek prestige premises and undertake a multitude of projects which, cumulatively, established them in the shape of the major organisations they are today.

Our own Society, eventually, may benefit in a similar way but it is important that we start by bringing to the notice of our members, particularly our long-standing members, this important way of contributing to the Society's work.

Several members lately, and their spouses, have already recognised this as a most acceptable way of making a contribution to the Society in a manner which they found very satisfactory. We hope that many more will do so.

Members who might like to consider donating to the Society, eventually, some gift of books, paintings, money, etc. by making provision for it in their Wills are invited to discuss it, first of all, with the Executive Secretary, who can supply some explanatory notes on the procedure to be adopted if necessary.

Gifts like this do not require making out a new will. An existing will can easily be altered to include the gift, simply by making out a Codicil. The Executive Secretary will explain this, too, if required.

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SPACEFLIGHT

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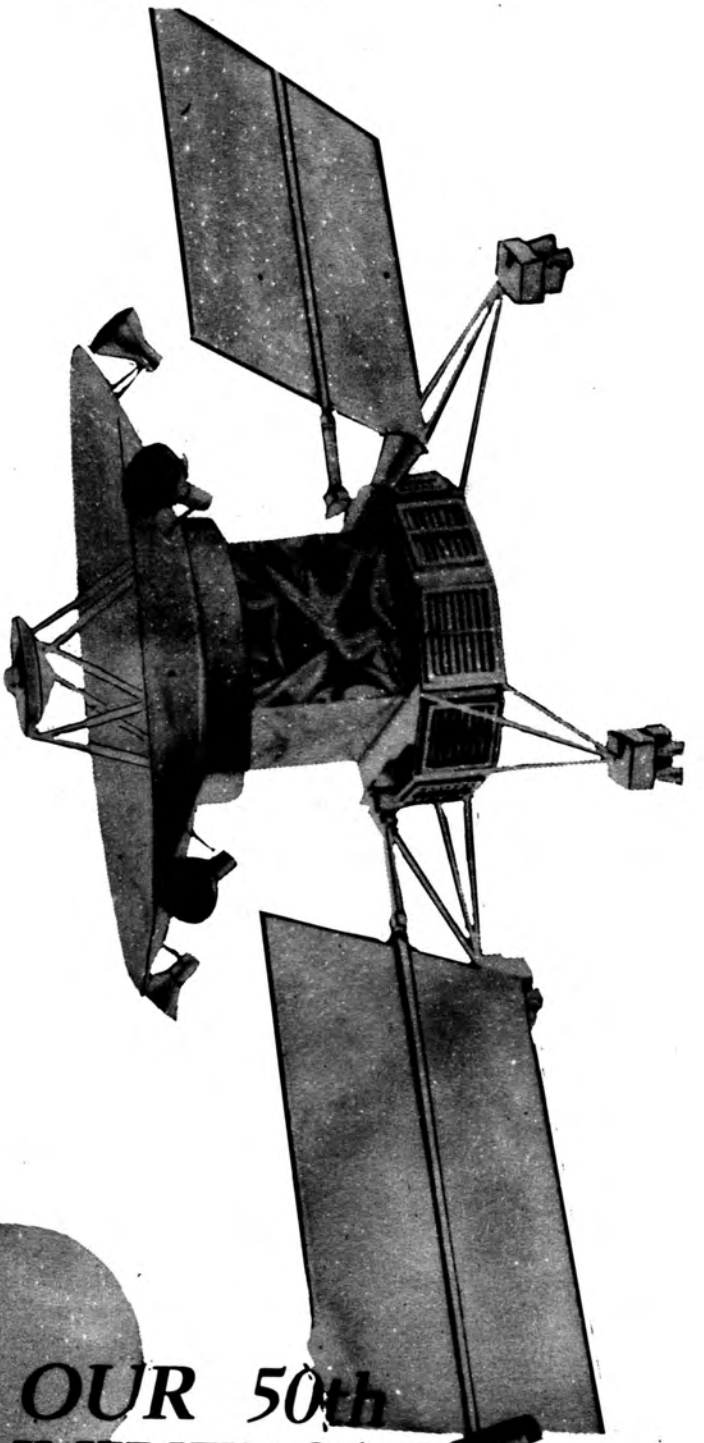

OUR 50th ANNIVERSARY YEAR

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MARCH 1983
VOLUME 25 NO. 3

JBIS

The monthly issues of JBIS cover a wide range of technical space topics with special issues on SPACE CHRONICLE; ASTRONAUTICS HISTORY; INTERSTELLAR STUDIES and ORBITAL DYNAMICS.

The contents of the issues following on from those published in the last list (*Spaceflight*, May 1982) are given below.

Members can obtain the 12 copies of JBIS for 1983 for £20.00 ($44.00), postage inclusive. Single copies of the 1982 issues may be purchased at £2.00 each ($4.00).

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April 1982 SPACE CHRONICLE

B. I. Edelson and R. D. Briskman	The Satellite Communications Outlook
D. G. Fearn	Electric Propulsion of Spacecraft
J. R. French and N. D. Hulkower	Exploration of the Asteroids
N. L. Johnson	The Early Orbital History of Satellite 1981-39A, Kosmos 1267
W. R. Maxwell	The Early History of Rockets
K. J. Rooney	The Future for Domestic Communications Satellites – Lease or Buy

May 1982 INTERSTELLAR STUDIES

A. Bond	On the Improbability of Intelligent Extraterrestrials
A. G. Smith	Settlers and Metals – Industrial Supplies in a Barren Planetary System
M. Taube	Future of the Terrestrial Civilization Over a Period of Billions of Years (Red Giant and Earth Shift)
T. J. Grant	Daedalus Probe Requirements and Deployment as a Function of Reliability
T. B. Tang	Fermi Paradox and C.E.T.I.

June 1982 SPACE CHRONICLE

L. E. Day	Orbital Flight Tests of the Shuttle
P. S. Clark	Future Developments of Soviet Launch Vehicles
C. R. Turner	Space Communications and the Impact of New Technologies and Systems
P. S. Clark	The Soviet Space Year 1981
J. Popescu	Remote Sensing of the Earth's Resources: The Soviet Experience
D. J. Shayler and T. Avery	Astronaut Assignments in the Mercury and Gemini Programmes (1959–1966)

July 1982 SPACE TECHNOLOGY

J. Carter *et al*	A Gamma-Ray Telescope for the 1980's
I. Bacon	A Method for Determining the Flight Readiness of the Integrated Space Shuttle System
D. G. Fearn	A Review of Future Orbit Transfer Technology
R. L. Staehle	An Expedition to Mars Employing Shuttle-Era Systems, Solar Sail and Aerocapture

August 1982 ORBITAL DYNAMICS

D. G. King-Hele	Lifetime Prediction for Satellites in Low-Inclination Transfer Orbits.
J. G. Walker	The Geometry of Satellite Clusters
D. G. King-Hele	The Value of Photographic Observations in Improving the Accuracy of Satellite Orbits
D. M. C. Walker and A. N. Winterbottom	Analysis of the Orbit of 1966-63A Near 15th-Order Resonance
P. Moore and D. Holland	Analysis of the Orbital Inclination of HEOS 2 Second-Stage Rocket 1972-05B
M. Waterman	Explanation of "Unidentified" Satellites 1966-00B and 00C
R. D. Eberst	The Crowding Skies

September 1982 INTERSTELLAR STUDIES

P. F. Massier	The Need for Expanded Exploration of Matter-Antimatter Rockets
R. L. Forward	Antimatter Propulsion
B. N. Cassenti	Design Considerations for Relativistic Antimatter Rockets
D. L. Morgan	Concepts for the design of an Antimatter Annihilation Rocket
R. R. Zito	The Cryogenic Confinement of Antiprotons for Space Propulsion Systems
G. Chapline	Antimatter Breeders

October 1982 SPACE CHRONICLE

C. P. McKay	Terraforming Mars
G. Simnett	The Turbulent Sun
A. Kenden	A New Military Space Mission
W. J. Stubno	The von Braun Rocket Team Viewed as a Product of German Romanticism
N. L. Johnson	The Development and Deployment of Soviet Geosynchronous Satellites
Y. Yamada	The Origin of Apollo-Amor Objects
J. W. Powell	Project Farside, America's First Space Venture
N. Kidger	India in Space: an Overview

November 1982 INTERSTELLAR STUDIES

P. Birch	Orbital Ring Systems and Jacob's Ladders – 1
E. H. Lemke	Magnetic Acceleration of Interstellar Probes
G. W. Pace	The Moon and the Ecosphere
R. T. Jones	Relativistic Kinematics for Motions Faster than Light
P. Birch	Radiation Shields for Ships and Settlements

December 1982 ASTRONAUTICS HISTORY

F. H. Winter	A New Look at Early Chinese Rocketry 1200's–1900
M. R. Sharpe	The Centenary of Robert Hutchings Goddard, 1882–1982
J. von Puttkamer	Skylab: Its Anguish and Triumph – A Memoir
F. J. Malina	Theodore von Kármán and the Development of Long-Duration Composite Solid-Propelland Rocket Engines
D. Dooling	A Third Stage for Space Shuttle: What Happened to Space Tug?

SPACEFLIGHT

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CONTENTS

101 Success for PAM

102 Space Report

104 News from the Cape
Gordon L. Harris

107 Satellite Looks Under the Sea

108 From "Friendship" to "Challenger"

110 Space at JPL
Dr. William I. McLaughlin

115 The Shuttle and Spy Satellites

116 Space Communications

117 Sweden in Space
Alan D. Farmer

126 Satellite Digest – 162
Robert D. Christy

127 Milestones

128 Correspondence

128 Book Notices

SPACE '82: AN OUTSTANDING SUCCESS

The Society's Space '82 weekend conference in Brighton shortly before Christmas proved to be a resounding success. More than 350 members, spouses and friends braved the wintry weather of an English seaside resort to hear a distinguished gathering of space experts present their views on the future of space exploration. Combined with a full social programme, Space '82 was warmly received by all concerned; indeed, expressions of thanks and congratulations were still arriving at the Society's headquarters months after the event!

Comments from delegates at the conference itself showed that the talks presented were of a very high standard and enjoyed by both layman and expert alike. In the coming months we hope to publish as many of the papers as possible, those of a technical nature will appear in *JBIS*, while those with a more general appeal will find their way into *Spaceflight*.

One of the first to be published will be George Mueller's fascinating contribution on antimatter propulsion, a concept which could reduce travel time around the Solar System to a matter of weeks, and possibly take Man to the stars. But that is for a future issue.

On another subject, a final appeal to all members: if you haven't already paid your 1983 subscription fees, then please do so. Fees are payable by 31 December of the year preceding. Late payers involve the Society in considerable expense both in money and staff time – a cost in the region of £5,000 – in sending out reminders and other work.

COVER

When the Venus Orbiter Imaging Radar (VOIR) mission was cancelled in January 1982 for budgetary reasons the Jet Propulsion Laboratory in California began work on a reduced version, the Venus Radar Mapper mission. VRM's radar could map most of the Venusian surface at a resolution of 1 km; the project has yet to be approved for a 1988 launch. The two Soviet Venus/Halley's comet probes of 1984/5 will now again carry balloon experiments for dropping into that planet's atmosphere *en route* to the comet; and a new Soviet Venusian mission with multiple small probes is reportedly being studied for 1989.

NASA/JPL

GOODBYE SPACE '82

Now our Space '82 Conference draws to a close. Organising a conference like this, we felt rather like the "Giotto" probe designers must feel. Everything was set and the date agreed some 18 months ago. The launch was quite smooth, the coast phase fairly quiet with one or two mid-course corrections, but the pre-encounter phase, as you can imagine, has been unbelievably busy.

Well, now we have had our conference encounter and I think we have returned a fair amount of high quality data. I am sure the analysis will go on for many months. You never know we may spot another distant conference one day and decide to send a probe to that.

All that now remains is for me to express my sincere thanks to all those who have helped us with this conference.

First, I should like to thank NASA for arranging for the first operational flight of the Shuttle to coincide with our weekend. Secondly, I should like to congratulate the Soviet Union for the considerable forward planning which must have been required to schedule the breaking of their space endurance record to occur this weekend.

On a more serious note I should like to thank all of our speakers some of whom have travelled many thousands of miles to make this such an interesting and exciting weekend.

Thanks also to the Mayor and Brighton Corporation for their wonderful hospitality and use of these excellent conference facilities.

Next I should like to thank Mr. Horwood of Western Glass for the marvellous Space '82 tankards which he presented to all our speakers. Thanks also to our exhibitors, ESA, British Aerospace, INMARSAT and British Telecom for their most interesting displays.

Next to the BIS and particular thanks must go to the Programme Committee for all the effort they have put towards the organisation of this conference. Particularly Tim Grant who has organised all the publicity and Gerry Phillips who you may have seen wandering around with his camera in his rôle as the Society's official recorder.

Next I should like to thank Shirley Jones, the staff of the BIS and the many volunteers who put in such long hours.

Finally, Len Carter. I should like to express particular thanks for his untiring efforts for making this weekend such a success. I do not know how many of you know him but Len is a truly remarkable man. He spends most of his time required in several places at once and this weekend for the first time I think I have seen more than one of him! Perhaps our distinguished member Arthur Clarke might have something to say about that.

Martin Fry
Chairman, Space '82 Organising Committee

The BIS President closed the proceedings:

In this Conference we have heard much and learned much. If it has caused only one person in all of the 350 or so here to have had only one new idea which could advance the Cause of Astronautics, then Space '82 will have achieved its objective.

I hope that Space '82 has left you with good impressions, happy memories, and a tumult of new ideas, or perhaps some new angles.

When the time is apposite, and we have a further set of appropriate and highly controversial subjects to discuss we will once again provide a forum, hopefully once again at Brighton. Until that time I sincerely wish you all Bon Voyage: a Good Journey.

. . . afterthoughts . . .

Sir, I have just returned from Space '82 and would like to thank the organisers for an interesting, entertaining and thought-provoking weekend.

MICHAEL BLACK
London

Sir, May I thank you for all your efforts in the organisation of the so successful Space '82 conference. I greatly enjoyed the opportunity of participating in it and renewing my friendships with many colleagues from overseas. It was certainly well attended and I think the audiences enjoyed all the presentations.

GARRY HUNT
London

Sir, The Conference was a resounding success and undoubtedly reflected the efforts of all those concerned. My heartiest congratulations to all.

ALAN LEWIS
London

Sir, As an American, I was mildly proud to see that Space '82 drew, as featured speakers, nine Americans, including Deke Slayton, whose grizzled head attests to his being the grand old man of American astronauts; Tom Paine, former administrator of NASA as well as the ebullient Bob Freitag, still enthusiastically with NASA.

The presentations of all the speakers were professional to the highest degree and, even more importantly, they were interesting and informative to layman and specialist alike.

MITCHELL SHARPE
Alabama, USA

Sir, May I take this opportunity to say that I thoroughly enjoyed the Space '82 conference. It was good to see such a smooth running series of talks without the usual overrunning of time that one normally encounters.

I was also impressed by the quality of the speakers; well done!

R. GREAVES
Beds

SUCCESS FOR PAM

The fifth mission of the Space Shuttle saw the first use aboard the reusable spacecraft of an important new addition to the family of rocket stages: the Payload Assist Module (PAM).

The new stage was privately developed by the McDonnell Douglas Astronautics Company as the first commercial space launch vehicle. The first PAM was pushed out by springs from the cargo bay of *Columbia* precisely on schedule on 11 November. It drifted with its SBS communications satellite payload for 45 minutes while the Shuttle moved to a safe distance. Then it began an 83 second rocket burn to boost SBS-3 towards geostationary orbit, approximately 22,898 mi (36,851 km) above the Earth.

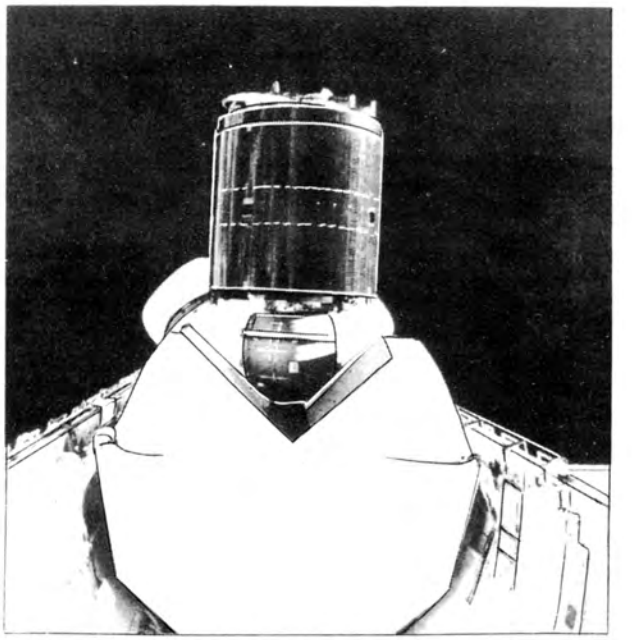
Twenty-four hours later, the launch was repeated with Telesat Canada's ANIK-C3 satellite. Both satellites were moved into their final operational circular orbits of about 22,300 mi (35,887 km) by built-in "apogee kick motors" a few days later.

The specially designed cradles that held the PAMs and their payloads in the cargo bay were returned to Earth by the Shuttle for use on future missions.

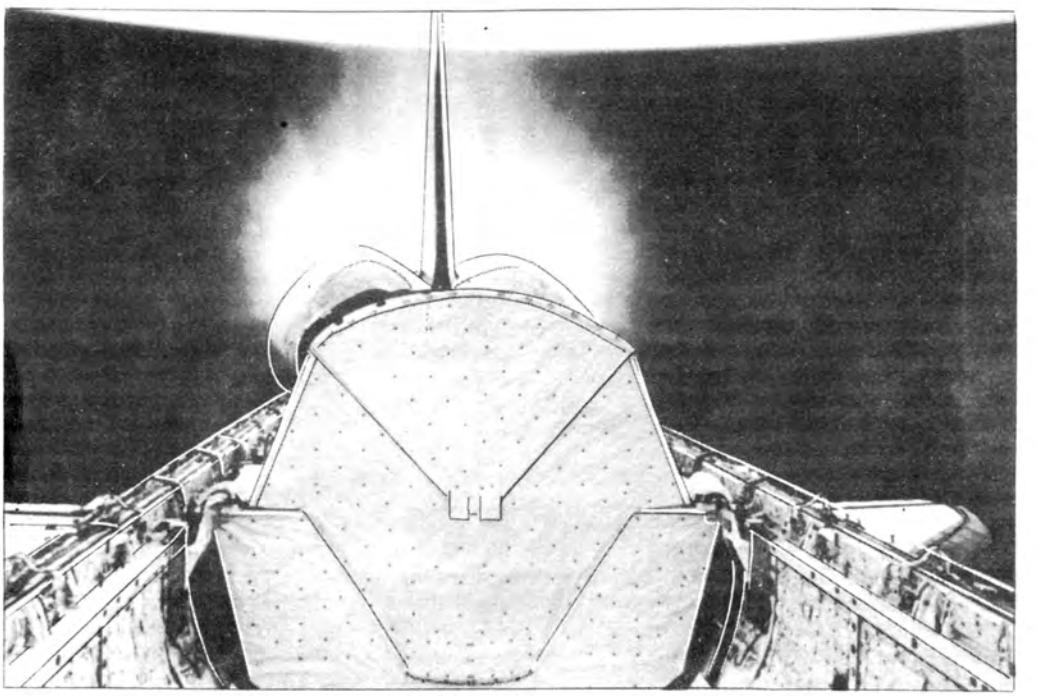
The mission aboard STS-5 marked the ninth and tenth launches for PAM since 1980. On the first eight, PAM operated as the third stage of the Delta launcher.

The next Shuttle mission for the Payload Assist Module will be aboard STS-7, scheduled for launch next April. Telesat Canada will use PAM again with the ANIK-C2 satellite, accompanied by a second PAM carrying the Indonesian communications satellite Palapa-B1.

Altogether, more than 60 PAM missions aboard the Shuttle may fly over the next five years. In addition to the PAM-D's 2750 lb (1274.5 kg) Delta-class payload capacity, McDonnell Douglas is offering two other PAM configurations to handle large Shuttle payloads: the recently announced PAM-DII for satellites of up to 3500 lb (1587 kg) and the PAM-A (Atlas Class) for those weighing up to 4400 lb (1996 kg).



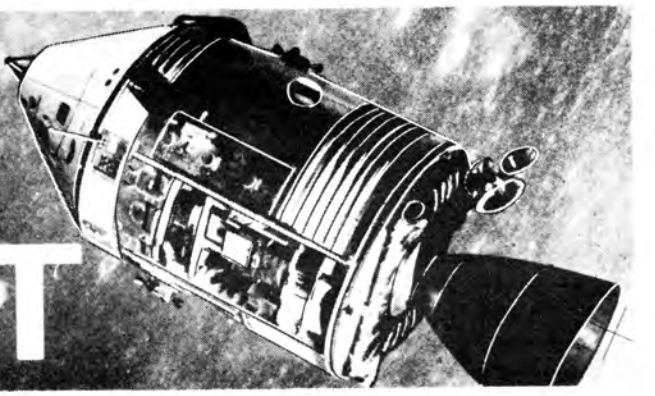
The spinning Payload Assist Module (spherical object just emerging from the cradle) and its satellite move away from the Shuttle last November.



A spectacular sight: *Columbia's* two Orbital Maneuvring System engines are fired to change the flight path. Earth is at top.

NASA/JTNS

SPACE REPORT



ASTEROID DISCOVERY

A new, large asteroid has been discovered which appears to be the remnant of a burned-out comet. Planetary scientist Eleanor Helin discovered the asteroid while conducting a search for some other objects using the Palomar Observatory's 48 in. Schmidt telescope.

"While this asteroid does not seem to be an easy candidate for a space mission because of its inclination and eccentricity," said Helin, "it is an exciting discovery because its orbit compares closely with the orbit of comet Encke and another asteroid, Hephaistos, and it is one of the largest asteroids ever found outside the main asteroid belt. Also, this object was discovered on its inward journey toward the Sun and thus will present an unusually long opportunity for observation and study. Its size, brightness (absolute magnitude of 15.6), and orbit make it an especially good opportunity for amateur astronomers around the world."

1982TA falls into the class of asteroids known as Earth-crossers or Apollo objects, because their orbits around the Sun cross the orbit of the Earth. This particular asteroid has spectral characteristics which helped to determine that it is a relatively large, dark object. It should be especially interesting to both professional and amateur astronomers because it will be visible during both spring and summer as it travels outward from the Sun.

SHUTTLE ENGINES

The three main engines from Shuttle Orbiter *Columbia* will next fly into space aboard a new Shuttle craft. According to Judson Lovingood, manager of the Space Shuttle Main Engine Project at the Marshall Space Flight Center, the engines will undergo a complete overhaul before they are reused again on Orbiter *Atlantis,* due for delivery late next year. These engines, which were operated at 100 per cent of rated thrust on *Columbia,* will be modified and retested to certify them for operation at 109 per cent aboard the fourth Orbiter.

The engines have been removed from *Columbia* and shipped back to the manufacturer (Rocketdyne Division of Rockwell International in Canoga Park, California). The first order of business was to carefully disassemble them. Then every part was to undergo inspection to determine wear and reusability. "We know that some parts will have to be replaced because of the increased temperatures and pressures they will see at the higher power level," said Lovingood. "But we would also like to see if the flight environment has a different effect on the hardware that we have seen in ground testing."

The engines will be reassembled and thoroughly checked before being shipped to the Marshall Center's engine test facility at the National Space Technology Laboratories for a series of acceptance test firings. These firings, tentatively schedule for autumn 1984, will include ignition, calibration and endurance tests. The engines underwent similar test firings before they were installed in the *Columbia.*

After the engines have been accepted for flight by the Marshall Center they will then be installed in *Atlantis* in time for its first mission in 1985. *Columbia* will receive three brand new engines for its next flight, the Spacelab mission in September.

SATELLITE POLLUTION STUDIES

NASA is using the latest remote sensing satellite technology to study hazardous-waste disposal sites north of San Francisco Bay. The four-year study is designed to test the technology of the new Thematic Mapper, launched last July aboard NASA's Landsat 4 satellite.

The Thematic Mapper data are being tested for their use in assessing hazards from more than 20 waste disposal sites located in the northern extension of San Francisco Bay.

The area has historically had a high concentration of major industrial facilities because of its proximity to railway lines and deep water ports. These industries generated and discarded a considerable amount of

waste, often on private property within an industrial facility, which made regulation difficult.

Thematic Mapper data will be used to study the area for water quality, stress on vegetation, land use, soils, surface geology, and topography.

TETHERED SATELLITE

Further steps have been taken towards building a "Tethered Satellite System", with the awarding of a $1 million contract to Martin Marietta Aerospace. If approved for final development, the Tethered Satellite System would be carried into orbit by the Space Shuttle in the late 1980's. There the satellite would be suspended from the cargo bay on a tether up to 100 km long, and would "troll" through the Earth's upper atmosphere to obtain magnetospheric, atmospheric and gravitational data. The satellite could also be deployed upward to study electrodynamic and other scientific phenomena.

Currently there are limited means by which the upper atmosphere (around 100 to 150 km up) can be studied. The area is too high for aircraft to reach and too low for satellites to remain in orbit for long.

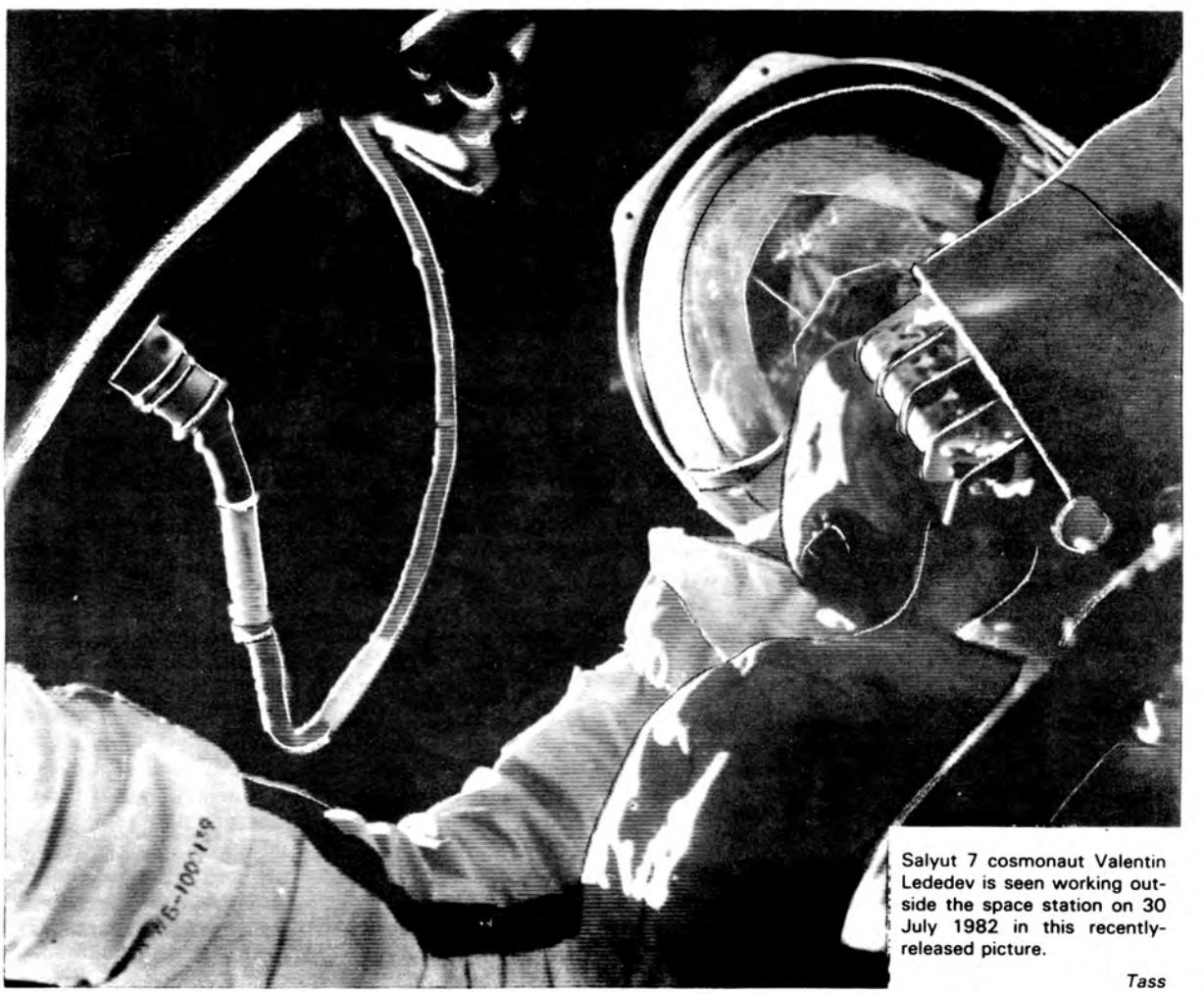
The negotiations for the contract will result in Martin Marietta performing an Advanced Development Phase, which entails more detailed engineering analyses and testing of the system, plus testing of some key components similar to those to be flown in space.

Further details can be found on p. 320 of the July/August 1982 issue of *Spaceflight*.

JAPAN'S THIRD METSAT

Japan's Geostationary Meteorological Satellite (GMS) programme will take a further step forward in August 1984 when the third satellite (GMS-3a) will be launched using the sixth N-2 vehicle. GMS-3a will be placed in geostationary orbit at 140° East longitude covering the Japanese segment of the World Weather Watch, writes Nicholas Staggall.

The GMS-2 prototype model will be used as the GMS-3a flight model although some refurbishing will be required. This work will be based on the experience gained from the flight model of the GMS-2 now orbiting the Earth.



Salyut 7 cosmonaut Valentin Lededev is seen working outside the space station on 30 July 1982 in this recently-released picture.

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NEWS FROM THE CAPE

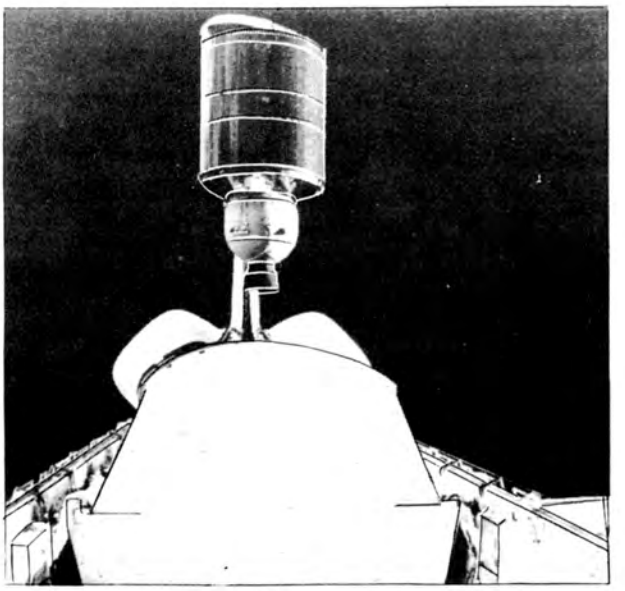
By Gordon L. Harris

PAYING THE PRICE

The cost of flying Space Shuttle missions will not be matched by the revenue from paying customers until 1986–7. That opinion was given by Lt. Gen. James Abrahamson, NASA associate administrator, during a press conference shortly before the fifth Shuttle mission. Launch costs have been largely kept secret for the last two years, during which NASA spokesmen avoided such questions. *Columbia* launched two commercial communications satellites on its first operational flight (STS-5), for which Satellite Business Systems paid $8 million and Telesat Canada $9 million. That adds up to about 7 per cent of the cost to NASA, estimated at $250 million for a five-day mission by Abrahamson.

The Shuttle director noted that SBS entered into the contract for its launch in 1977 at a time when NASA charges were being formulated based upon rather optimistic assumptions, such as there being only two weeks between flights and the availability of five Orbiters. Recently, Dr. Stanley Weiss, in charge of pricing, admitted that the rates were unrealistic. So for payloads launched between 1 October 1985 and 30 September 1988 NASA expects to recover $71 million (1982 dollars). The agency has said, "Most non-Government payloads during that period, as is the case for missions through 1985, will be telecommunications satellites that require only a portion of Shuttle launch capability. Such launches are priced according to a shared flight formula."

A Delta-class payload launched into geosynchronous orbit will cost about $26 million, while for a heavier satellite, like those carried by Atlas Centaur, the price will be about $41 million. And NASA hopes that its rates will be competitive with the two US expendable vehicles and the European Ariane.



What it's all about; deploying a satellite from the Shuttle cargo bay.

A second important question: when will a Shuttle carry its advertised payload of 65,000 lb (29,500 kg)? This was answered by Glynn Lunney, Johnson Space Center flight operations director. He estimated the STS-5 payload at 15,900 kg (4,500 kg for each satellite including cradles and related accessories). For STS-6, *Challenger's* first mission, the payload capacity was about 22,700 kg, because of a lightweight External Tank 3,200 kg lighter than earlier models and up-rating

A lighter moment from the fifth Shuttle mission; Brand (holding card), then clockwise, Lenoir, Overmyer and Allen.

NASA/JTNS

the main engines to 104 per cent of normal thrust. In addition, *Challenger* is some 1,500 kg lighter than *Columbia*.

By mid-1983, when *Challenger* carries Insat, an Indian communications-meteorology satellite, plus a second Tracking and Data Relay satellite for NASA, payload capacity will increase to 27,000 kg because of higher performance solid boosters (adding 1,400 kg to the capacity) and the continued use of higher thrust levels. Thereafter, Lunney added, those engines will operate at 109 per cent, and that means up to 2,700 kg more capacity – the 29,500 kg maximum which NASA forecast when the programme began.

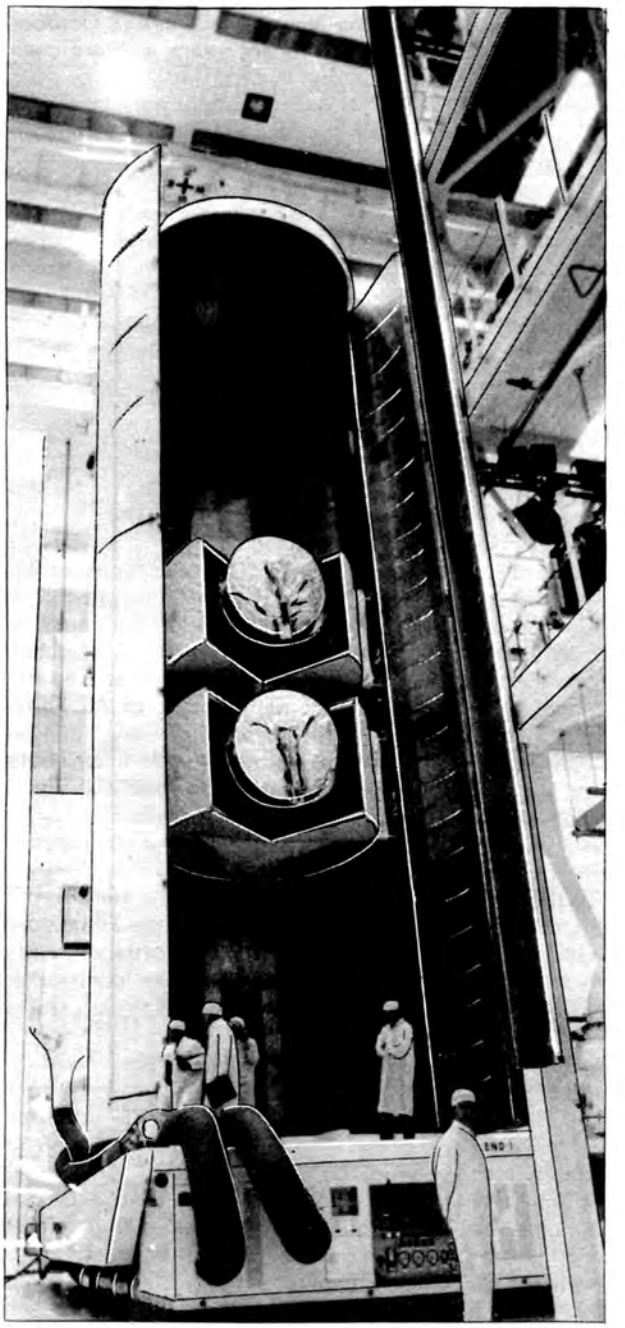
General Abrahamson made other interesting comments. Discussions are continuing, he said, with the Space Transportation Co., an investment firm which offered to raise $1,000 million to buy a fifth Orbiter for NASA's use. In return, the agency would be expected to turn over to the company the marketing of Shuttle cargo space for all commercial (i.e., non-Government) payloads. "In December or so," Abrahamson explained, "we expect to reach a mutual decision as to what is in the nation's best interests as well as those of the company." He also mentioned that NASA has several proposals from other firms concerning the Delta and Centaur expendable vehicles.

NASA's revised policy concerning the use of Payload Specialist astronauts aboard the Shuttle was interpreted by Abrahamson as meaning that "any major customer" can designate a specialist responsible for care and deployment of his satellite in orbit. "He or she," the general explained, "will receive minimum training in safety procedures and crew relationships. The purpose is to enhance mission success." Meanwhile, a NASA Advisory Council will investigate the requirements for future Shuttle travel by selected volunteers; artists and news people were mentioned.

There may be five Shuttle flights in 1983. *Challenger* will fly three while *Columbia* undergoes modifications at the Kennedy Space Center before carrying Spacelab in September. Abrahamson said that schedule will require 20 or more astronauts (he saw no need to increase the present corps of 75). The payloads include three communications satellites, two tracking and data relay spacecraft (using the large Inertial Upper Stage), Spacelab and a possible Defense mission in November. A military payload specialist will accompany every Defense satellite.

The General's remarks about space walks took on new meaning after STS-5 during which the first Shuttle EVA was called off because of spacesuit failures (a circulating fan in one, pressure deficiency in the other). While NASA has not planned EVAs on every mission, Abrahamson said that the agency does intend to "step up" such work simply to acquire experience. In just over a year, a crew will attempt to rendezvous with the failed Solar Maximum Mission solar observatory and repair it in orbit. He pointed out that the US leads the USSR in space walks by a 5-1 ratio and said that "we want to exploit that advantage."

Shuttle-era suits developed by Hamilton Standard for NASA at a cost of well over $100 million are designed to allow greater mobility for astronauts during complex jobs in orbit, such as assembling structures.



Satellites intended for installation on the Shuttle are first mounted in the "payload canister", essentially a copy of the Shuttle bay itself, and then transferred on the pad. Here, the SBS-3 communications satellite sits above the Canadian Anik C-3.

NASA

CHANGING ATTITUDES

The distinctions between NASA's civilian-directed space activities and those of the US Air Force have become increasingly blurred now that the Space Shuttle has reached operational status. The Kennedy Space Center's offices, firing rooms and corridors where uniforms were formerly rare sights today accommodate larger numbers of Air Force officers. They reflect chang-

ing policies noted by the *New York Times* (3 October 1982) in these words: "In recent years, military uses of space have expanded rapidly. For the fiscal year just ended, the budget of NASA contained more funds for military operations than for civilian for the first time in its history."

'In that context, a marked difference in policy has emerged between NASA top management and the Congressional committee that authorises agency budgets. While the latter body wants the Air Force to absorb a larger share of Shuttle costs, arguing that military requirements dominate the launch schedules, Dr. Hans Mark, deputy NASA administrator, prefers to have those funds (or as much of them as feasible) under agency control. With the purse strings in hand, in simpler terms, agency planners will have more clout when dealing with the military.

Whatever the outcome, things will hardly be the same at this major launch base where, traditionally, military involvement was played down in favour of emphasising the peaceful uses of outer space. During the Johnson era of the 1960's those playing host to foreign dignitaries were regularly cautioned by the State Department to forego any mention of military launches from the Cape. Heads of state were driven around the sprawling complex but not within sight of Air Force launch towers. Ranking officers of military services might have been invited to witness Apollo lunar shots but so were educators, industrialists, politicians and scientists—not to exclude Hollywood performers who, as a matter of fact, got more press attention than the other categories.

The change became vividly apparent before the fourth Shuttle launch when an Air Force general officer outlined military policies concerning Shuttle payloads to media representatives assembled at the launch site. It was a noteworthy first in the history of the US space programme.

Related or not, two other recent events point to changing attitudes. In July the US Army launched its first Pershing II missile from the Cape in the presence of television and press. The failure (later attributed to a faulty motor casing) was duly publicised. And on 30 October the Air Force launched its new Titan 34D with the brand new $500 million Inertial Upper Stage powering two military communications satellites into orbit. Here, too, the military invited media coverage although, for years, such launches have been conducted in secrecy.

The newest version of the Titan is described as an essential backup for Shuttles which were at least two years late in reaching operational status. And IUS will see double service as an upper stage for both military and civilian payloads taken aloft in Shuttles.

The *NY Times* focused attention on an important aspect of the civilian vs. military concerns in future space spending. "Military space spending is projected to rise faster than the overall defense budget for the next five years. As a result, many research projects of scientific value are being squeezed out."

Whereupon the newspaper asked eight men active in space science to suggest which projects they favour: former NASA boss James Fletcher; Riccardo Giacconi, director of NASA's Space Telescope Institute; Prof. Thomas Gold of Cornell, retired Houston director Christopher Kraft, Prof. James Van Allen of Iowa; Chairman D. J. Fink of the NASA Advisory Council, Chairman Thomas Donahue of the National Research Council's space science board and James Plummer, vice president of Lockheed.

The most interesting fact to emerge from their responses was opposition to manned ventures vs. automated spacecraft. While several mentioned space platforms or stations, others urged unmanned planetary excursions, long-term solar observation and more effort in measuring Earth resources.

So there is no immediate concensus within the scientific community about future programmes. Meanwhile, NASA and its major contractors continue to push for a platform that would assure future Shuttle traffic from this East Coast location. Military interest in polar orbit missions will require launchings from Vandenberg Air Force Base in California which will become available in 1985.

As one more straw in the wind, NASA announced in late October that the same operations contractor selected for Kennedy Space Center Shuttles will perform similar functions for the Air Force at Vandenberg. Again, the formerly separate programmes are moving together at accelerated pace.

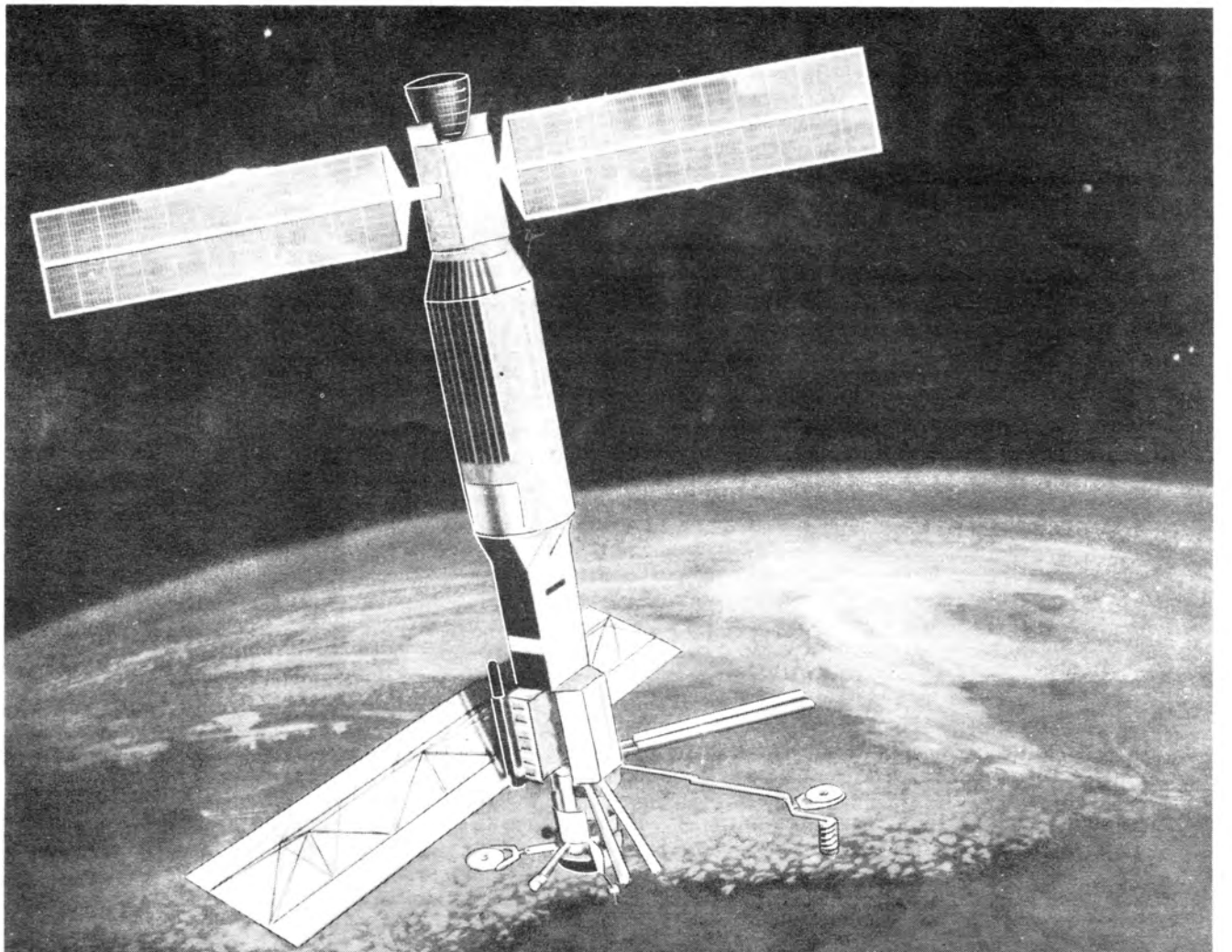
TIMES GONE BY

A story from Moscow concerning the development of a super booster capable of orbiting a large space station touched off a flood of memories for the remaining active members of the Apollo Saturn launch team. They recalled Nova, a 12 million pound thrust booster, proposed by the von Braun team in 1960. Had it been built, it could have propelled men directly to the lunar surface (81,000 kg payload to escape velocity and 6,800 kg Earth return). Its first stage required eight of the kerosene engines later used in the Saturn V plus four hydrogen engines in the second stage and one each in the third and fourth stages. In the early Sixties, looking ahead to such a monster, the NASA launch planners laid out a third pyramid-like pad in Mosquito Lagoon, a 40,000 acre area north of Pads A and B. The big pad was never built. Retired KSC Director Kurt H. Debus believed it would be needed at some future time for the so-called "big dumb booster," a solid propellant rocket to lift large masses into orbit. The motors, Debus concluded, would be so massive they would have to be produced at the Cape.

SHUTTLE PROCESSING

Competition is heating up for the prize contract to process Shuttles for launch at KSC and Vandenberg Air Force Base in California. Four firms led by Rockwell have joined the fray: Boeing, Martin Marietta, United Technologies and United Airlines. NASA are calling for bids now and hope to award a contract by early 1984. Lockheed heads a competing group. Agency spokesmen estimate that the winner will hold the job for 10 years and receive up to $500 million.

SATELLITE LOOKS UNDER THE SEA



Major geological features on the ocean floor are shown in images recently produced from data collected by the Seasat oceanographic satellite flown by NASA in 1978. Each image represents a global snapshot of the sea floor in a way never before possible and at least one previously unknown feature has been revealed. The images were produced by measuring the shape of the *surface* with the satellite's altimeter.

The global image consists of more than 50 million physical measurements including 10 types of corrections for atmospheric and other interferences. They were produced from the same data, but each was processed differently to emphasise a unique set of features.

The images supply new, detailed bathymetric (water depth) and geological information for wide areas of the world's seas. This is especially true in the southern oceans which have been poorly surveyed. For example, existing bathymetric charts show the "Louisville Ridge" as a discontinuous chain of mountains running southeast of the "Tonga-Kermadic Trench." The Seasat image of this region clearly shows a nearly continuous chain of features.

Seasat collected 70 days of oceanographic data over a 100 day period. The radar altimeter measured the distance from the spacecraft to the ocean surface. By calculating the satellite's position, and correcting for passage of the radar beam through the atmosphere, the height of the ocean surface, relative to a reference ellipsoid, was determined.

Mapping the sea *floor* by measuring the sea *surface* topography is possible because of the relationship between gravity, the sea floor and the ocean. Gravity over the Earth is not constant and varies depending on the local thickness, density, age and geology of the crust. The ocean conforms to variations in this uneven gravity field because it is a fluid and sea surface topography dominantly conforms to the sea floor topography. A mountainous formation on the sea floor, for example, causes a peak on the ocean surface detectable by a satellite altimeter.

NASA is considering a follow-on mission called Topography Experiment for Ocean Circulation, TOPEX, to study the ocean's circulation with a high resolution satellite altimeter.

FROM "FRIENDSHIP

21 YEARS OF AMERICA IN ORBIT

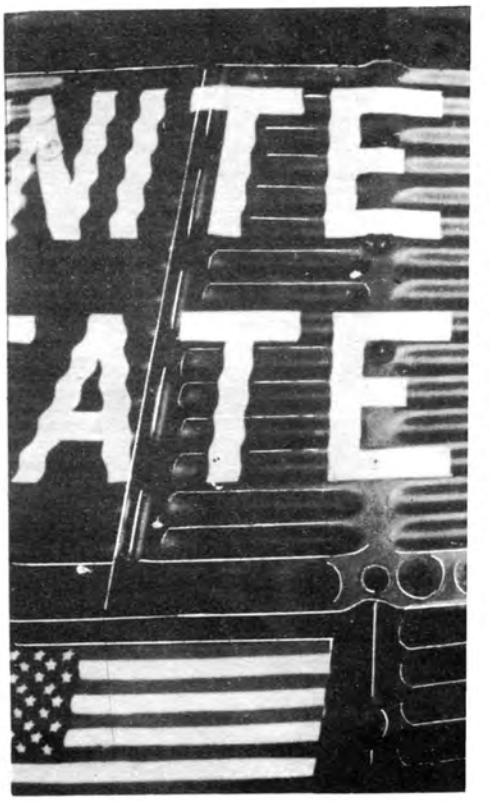
This February marks the coming of age of American manned orbital flight. Alan Shepard and Gus Grissom made successful suborbital trips in May and July 1961, respectively, but it was John Glenn who entered the history books as the first American to reach orbit. Glenn was originally to have flown another suborbital "hop" atop a Redstone booster but the previous successes and recent spectacular Soviet achievements brought orbital flight forward in NASA's schedule.

Glenn and his backup, Scott Carpenter, plunged into intensive training for a 16 January 1962 launch but bad weather and difficulties with the Atlas booster delayed liftoff until 20 February.

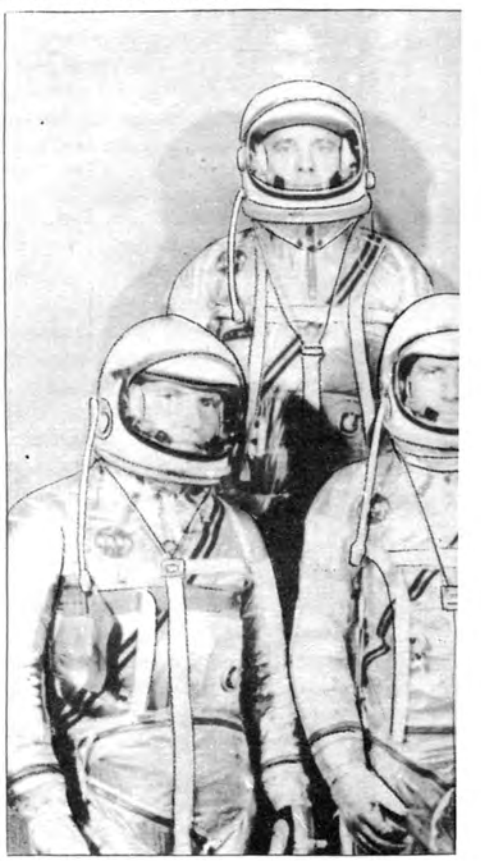
Friendship 7 went into a 161 × 262 km orbit and Glenn began testing his capsule's control systems, only to find that one of the automatic thrusters refused to work properly. He had to spend the rest of the flight controlling attitude manually.

Back on the ground, an indicator light seemed to show that *Friendship 7*'s heatshield had separated (as it was supposed to do shortly before splashdown). Glenn was advised to leave his retrorocket package attached during reentry in the hope that its straps would hold the heatshield onto the rest of the spacecraft. At the end of 4½ hours and three orbits the three retrorockets fired to bring *Friendship 7* back into the atmosphere; the warning light proved to be wrong and Glenn was safely recovered by *USS Noa*.

Glenn never flew in space again; he left NASA in 1964, after working on the early stages of the Apollo Lunar Module, and turned to politics. He became the Senator for Ohio and is now working towards the Democratic Presidential nomination for 1984. In the 21 years following his epic flight there have been a further 33 manned US space missions (three Mercury, ten Gemini, 15 Apollo and five Shuttle), six of which landed men on the Moon.



Below: the seven Mercury astronauts (six were originally From left to right: Walter Schirra (Mercury MA-8, Gem (Apollo-Soyuz); Gus Grissom (Mercury MR-4, Gemini 3); Scott Carpenter (Mercury MA-7).



STARPROBE

Unlike ISPM, which will observe the Sun from a distance, Starprobe will travel to our nearest star to observe it at close range. Starprobe is an advanced-technology mission that, if financed, is being planned within NASA's Office of Space Science and Applications to approach the Sun as close as 2½ million km sometime in the 1990's. The Starprobe study, begun in 1978, is being conducted for NASA by JPL.

Starprobe's scientific experiments can be grouped into three sets: gravitation and relativity, fields and particles, and optical sciences.

To achieve the high accuracies necessary for measuring the Sun's oblateness (the flattening of the sphere, with a bulge around the equator), and relativistic parameters for the gravitational experiment, a "drag-compensation" system will be carried. This is a new device consisting of a spherical mass free to move inside the satellite in a protective cavity. This means that the mass is unaffected by, for example, light pressure from the Sun. The rest of Starprobe, however, will be affected and measuring the movement of the mass inside its cavity will allow scientists to separate the effects of gravity and those of other forces. The gravitational field around the Sun is affected by the solar oblateness so accurate measurement of the former will allow calculation of the latter. The system is very sensitive. For example, the "J2 oblateness factor" will be determined to one part in one hundred million. However, the system will also respond to such onboard activity as sloshing of fuel in the tanks. These must be recorded so that their effects can be accounted for in the data analysis. A new concept in radio tracking with an onboard "doppler extractor" will also be needed.

The fields and particles experiments will, like ISPM, study the solar wind and magnetic fields, but the measurements will take place within the corona itself.

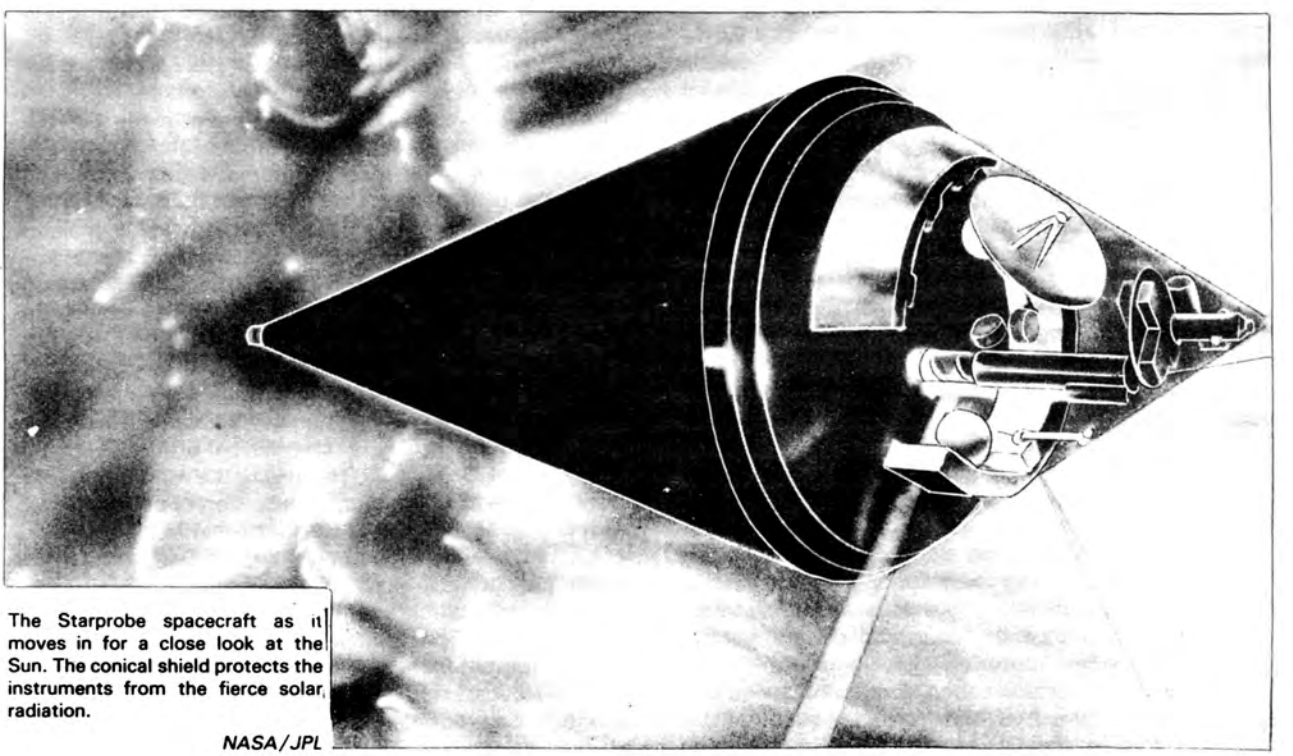
The optical experiments will study the structure and dynamical behaviour of the photosphere, chromosphere and corona at a resolution of better than 10 km.

Two other major technological problems must be solved in the Starprobe design: construction of a heat shield and the development of a communications system that will make itself heard above the hiss and crackle of the solar corona. The conical heat shield will dissipate heat by allowing its material to vaporise at the rate of 9 g/hr at perihelion. Testing of a shield prototype, made from carbon-carbon, is presently under way at Odeillo-Font Romeu in France at the world's largest solar furnace.

It is not easy to lose energy to drop in close to the Sun, so once again the familiar trek out to the kinetic energy dealer of the Solar System, Jupiter, will have to be made. The inclination of the trajectory will be close to 90 degrees, resulting in a polar pass of the Sun in order to observe the coronal holes. The pass also yields the best gravity-measurement results.

Thirty days from perihelion the observatory phase of the mission will begin, switching to the far encounter phase at ten days or 0.5 AU (the closest approach to the Sun, to date, was accomplished by the US-West German Helios at 0.3 AU), with heavy emphasis on fields and particles measurements. The near-encounter phase starts at four days, with optical observation of coronal holes. Finally, passage from pole to pole of the Sun takes place in only 14 hours.

The Starprobe study is being managed by James E. Randolph of JPL.



The Starprobe spacecraft as it moves in for a close look at the Sun. The conical shield protects the instruments from the fierce solar radiation.

NASA/JPL

FIRST MISSION TO A COMET

The most dramatic example of using a working spacecraft for a purpose other than originally intended took place when the Apollo 13 Lunar Module was used as a "lifeboat" after the near-fatal explosion which crippled the Command and Service Modules. Now another major redirection of a spacecraft will occur with the planned transfer of NASA's International Sun-Earth Explorer-3 (ISEE-3) from near-Earth space to a close flyby of the periodic comet Giacobini-Zinner (see the January issue, p.9). This encounter will take place on 11 September 1985, about six months before the encounter of the European, Japanese and Soviet spacecraft with Comet Halley.

After the proposal for the new use of ISEE-3 had been made by Robert Farquhar of the Goddard Space Flight Center (GSFC), four main groups worked together to produce the decision to redirect the spacecraft: NASA Headquarters, GSFC (which manages and operates ISEE-3), the Space Science Board of the National Academy of Sciences, and the Comet Subcommittee of the ISEE Science Working Team (this team also includes representatives for the first two ISEE spacecraft, which are still operative).

The Comet Subcommittee is an eight-member group chaired by Dr. Edward Smith of JPL, who is also the Principal Investigator for the magnetic field investigation and a Co-Investigator in the plasma-wave experiment of Dr. Fred Scarf of TRW; both experiments are on board ISEE-3. I recently visited Ed Smith in his office at JPL to discuss the project.

"The Comet Subcommittee was formed because of the relatively large size of the Science Working Team: about 40 members representing the three ISEE spacecraft." He said that there were three basic options considered by the Subcommittee:

(1) leave ISEE-3 in the Halo orbit about the Earth-Sun L1 Lagrangian point (The L1 point lies between the Earth and Sun, 1.5 million km from the centre of the Earth. There are five Lagrangian points in the Earth-Sun system, and they provide relatively stable points at which to park a spacecraft. The Earth-Moon system's L5 point has been proposed by several investigators as a point at which a space colony might be established.)

(2) move ISEE-3 from its Halo orbit and into the "geotail" (Earth's magnetic field tail) region, downstream in the solar wind, for 6 to 12 months and then back to the Halo orbit

(3) explore the geotail region as in (2) but then proceed to Giacobini-Zinner instead of returning to the Halo orbit.

Some investigators claimed that the first option would have resulted in the highest scientific return from ISEE-3 because of the importance of continual monitoring of the solar wind as the Sun's activity cycle declines. The second and third options, which include exploration of the geotail, make possible the simultaneous measurement of the near and distant geotail with all three ISEE spacecraft. According to Smith, the main factor that resulted in the selection of option (3), cometary exploration, by NASA was "the policy of the Space Science board to encourage exploration which will result in new science."

Comet Giacobini-Zinner *US Naval Observatory*

The Comet Subcommittee issued a detailed analysis of the alternatives in June 1982. Subsequent presentations that summer by Subcommittee members to the Space Science Board, chaired by A. G. W. Cameron, and to the Astrophysics Division at NASA Headquarters were primarily for option (2) or option (3) by different Subcommittee members. Smith himself recommended the comet exploration option, and this was also the recommendation to NASA by the Space Science Board. In retrospect, it would seem difficult for NASA to ignore an opportunity to encounter a comet for an extra cost of only $1.5 to $2 million, or about 1 per cent of the cost for a conventional mission.

Six of the satellite's 13 instruments will investigate the fields and particles around Giacobini-Zinner; the remaining seven will return no useful data – they were not designed for this job. Nor will ISEE-3 send back any pictures of the comet such as are planned for all of the Halley spacecraft (the Japanese will have a simple, line-scan imager working in the ultraviolet). However, it will see into the comet's tail, something that none of the Halley missions can achieve.

Smith's "vector helium magnetometer", making measurements of the local magnetic field in the frequency range between 0 and 3 Hz, will map the warping of the interplanetary magnetic field lines which, he says, "are draped over the comet like ropes." The field lines begin in the Sun and extend for tens of astronomical units (AU) outward. The mission as a whole will achieve one of the three primary scientific objectives established earlier by a committee of the National Academy of Sciences: "to investigate the interaction between the solar wind and the cometary atmosphere.'

It is interesting to note that for the 1985 encounter, coordinated measurements are possible from three other spacecraft: Space Telescope, Spacelab (ultraviolet instruments) and the International Ultraviolet Explorer (IUE). The opportunity also exists to make use of the International Halley Watch (see "Space at JPL" in the November 1982 issue) to observe Giacobini-Zinner, but additional NASA funding would be necessary.

The use of ISEE-3 to study comets will not be restricted to Giacobini-Zinner but will also include Comet Halley. After the spacecraft has flown through the tail of Giacobini-Zinner there will be two opportunities for ISEE-3 to make field and particle measurements in the solar wind upstream of Halley at the same time that Earth-based or space observations are underway. These alignments will occur on 31 October 1985, before Halley reaches perihelion (closest point to the Sun), and on 31 March 1986, after perihelion.

Tracking and data acquisition will be provided by JPL's Deep Space Network. The Arecibo radio telescope could also receive signals during the intercept, but NASA is not presently planning to pay for such a modification.

ISEE-3, weighing 460 kg and launched in August 1978, is spin-stabilised at almost 20 r.p.m. and uses hydrazine for propulsion and attitude control. A large amount of propellant (94 kg) was carried at launch as protection against launch errors, which would have severely affected the mission. However, the Delta launch was very accurate; the surplus propellant will now allow the trip to Giacobini-Zinner.

Giacobini-Zinner is a short-period comet (6.6 years) with perihelion at 1.03 AU and aphelion at 6.00 AU. It is inclined 31°.9 to the ecliptic and has a distinctive, narrow ion tail which develops near 1.7 AU and reaches a length of approximately one million km. It was discovered in 1900 by M. Giacobini and rediscovered in 1913 by E. Zinner

SATURN'S RINGS

The rings of Saturn have always been a fertile subject for interaction between observation and theory. Galileo discovered them in 1610, but it was Huygens who recognised in 1655 that the handle-like objects on each side of Saturn were actually rings encircling the planet. In 1857 Maxwell, who later made fundamental contributions in kinetic gas theory and electromagnetism, showed theoretically that the rings could not be solid nor liquid without breaking up, thus establishing by inference that they were made up from particles.

Before the Voyager and Pioneer encounters with Saturn most observational and theoretical work focused on the discovery and explanation of narrow gaps in the rings, e.g., the Cassini and Encke divisions. A hint as to the complexity of the structure came with the discovery of the F-ring by Pioneer 11 in 1979; but no one was prepared for the intricate hierarchies of rings, wave patterns, spokes, and even braids that were revealed by the cameras of Voyagers 1 and 2 in 1980 and 1981, respectively.

However, the sharpest resolution of the ring has been provided not by Voyagers' cameras but rather by the "photopolarimeter subsystem" (PPS). The PPS was able to measure features in the rings 20 to 50 times smaller than those recorded by the cameras. In order to accomplish this, the PPS was pointed at the star Delta Scorpii shortly before closest encounter. The star appeared to slide behind the rings along a 80,000 km radial section, from the surface of Saturn outward through the F-ring, as Voyager flew through the system.

The PPS measured the variation in brightness of the star as the light was blocked by varying amounts of ring material. Taking readings 100 times per second, the PPS achieved a resolution at the 100 m level.

The instrument still could not see the smallest structures, and one of the main theoretical difficulties is to explain how matter comes to be collected in such narrow, tight rings as the PPS has revealed: viscous, dissipative, and density wave phenomena may need to be invoked in order to provide the complete explanation.

The Principal Investigator for the PPS, Dr. Arthur Lane of JPL, and his Co-Investigators reported the basic results from the experiment in the 29 January 1982 issue of *Science*. However, the instrument produced such a wealth of data that the analysis is still under way.

One purpose is to provide theoreticians with a base for investigations of the ring dynamics. To this end, the data are being calibrated and a plot of the optical depth (a measure of the amount of ring material) versus distance from Saturn will be issued: first at a resolution of 60 km and later at 4 km.

The full resolution of the PPS will be used in a search for "rocks" amongst the finer-grained material. Theoretical studies of the instrument's response to various-sized spherical objects blocking a star's light will allow us to recognise the "signature" of a rock in the data. The data stream will then be searched for such signatures, and it may be possible to identify solid objects as small as 300 m, using only three data points.

EXTREME ULTRAVIOLET EXPLORER

The visible portion of the electromagnetic spectrum extends from about 4000 to 7000 Å (the angstrom unit Å is equal to 10^{-8} metres) with the infrared and radio portions lying on the long side of the visible, and the ultraviolet, extreme ultraviolet, X-ray, and gamma ray portions lying on the short side. The Extreme Ultraviolet Explorer (EUVE) satellite is planned by NASA to conduct an all-sky survey in the EUV spectral region from 100 to 1000 Å. The phrase "extreme ultraviolet" refers to the fact that the location of that region is at the extreme end of the ultraviolet, as measured from the visible portion of the spectrum. EUVE differs from the presently-operating International Ultraviolet Explorer (IUE) in that the latter satellite covers the range from 1100 to 3200 Å and is used to observe specific astronomical sources as opposed to providing an all-sky survey.

A gas at a temperature of 10^5 to 10^6 K will radiate in the EUV region; the Sun's corona provides a well-studied example. However, before the 1975 Apollo-Soyuz mission it was thought that EUV radiation from sources outside the Solar System would be absorbed by interstellar hydrogen. The four cosmic EUV sources discovered by the telescope onboard Apollo-Soyuz were visible because the interstellar medium differs from earlier estimates in two significant ways; it is less dense than earlier predictions of one atom per cubic centimetre, and it is not uniformly distributed. In fact, it is probable that in our local region of the Galaxy the amount of absorbing material is anomalously low. Dr.

Robert Stern of JPL has listed possible objects that EUVE might observe within about 300 light years from the Sun: emission from the transition regions and coronae of tens of thousands of stars; an unknown number of hot, white dwarfs; 100 or more binary stellar systems with mass transfer (dwarf novae such as SS Cygni); flare stars; nuclei of planetary nebulae; hot OB subdwarfs; and, potentially the most rewarding, currently unknown classes of objects.

EUVE has been assigned to JPL by NASA's Office of Space Science and Applications for Phase B studies after which a formal project start is planned. Astronomical instrumentation for the satellite will be provided by the University of California at Berkeley, under the direction of the Principal Investigator, Professor Stuart Bowyer. It was the Berkeley group that conceived and executed the successful Apollo-Soyuz experiment.

Current plans call for a launch in 1988, but this date is dependent upon funds available from the Explorer Program of NASA. Since the Explorer budget is based on the principle of allocating a constant number of dollars per year to the entire programme, the funds consumed by an ongoing Explorer project, such as IRAS (Infrared Astronomical Satellite) or COBE (Cosmic Background Explorer), can affect the funds available for a later Explorer project, such as EUVE. On the whole, this method of funding provides a highly stable fiscal environment and allows NASA to conduct a planned programme of scientific research using Earth satellites. It is interesting to speculate on the stability that might result for planetary exploration if the same method of constant-dollars-per-year was used there. The Mariner Mark II mission (see "Space at JPL" for September-October) is being designed with this type of funding in mind.

The EUVE satellite will be placed in a low Earth orbit at about 600 km altitude. Orbital inclination will be approximately 28° to the equator, and command and communications will be conducted through the orbital Tracking and Data Relay Satellite System (TDRSS).

The satellite will be spin stabilised with the spin axis electromagnetically torqued to continually point toward the Sun. Then the three telescopes, which point radially outwards from the spin axis, will complete coverage of the celestial sphere after six months of operations. Each point of the sky will be observed many times since the satellite will be spinning at several rpm. Three telescopes will be used for the sky survey in order to obtain information about three subspectral regions of the EUV. The 20 in Wolter-Schwarzchild telescopes are tailored for these spectral regions by the use of very thin filters over their apertures. It is currently necessary to use grazing-incidence optics for EUV astronomy since EUV photons which impact mirrors at near-normal angles are absorbed instead of being reflected (See "X-Ray Optics" by James H. Underwood in *American Scientist* **66,** p. 476, 1978; EUV and X-ray optics are similar.)

Once the EUV photons have been collected and focused by the optical system, they will be counted by a large array of extremely small photomultipliers contained in a so-called microchannel plate.

The astronomical data are to be stored on tape recorders and relayed to Earth when one of the two relay satellites is in view of the EUVE antenna.

The manager of the EUVE project is John Paulson, who also directs the Solar Mesosphere Explorer (SME) now in orbit and collecting data relevant to ozone balance and dynamics in the Earth's atmosphere.

WIDE FIELD/PLANETARY CAMERA

When Space Telescope (ST) is launched in 1985, one of the five science instruments it will carry is the Wide Field and Planetary Camera system designed and built by JPL and Caltech.

The system consists of two cameras of different focal lengths sharing the same housing and electronics. The wide-field camera is an f/12.9 instrument with a total field-of-view of 160×160 arcseconds, while the planetary camera is f/30 and 68.7×68.7 arcseconds. The cameras each cover the very broad spectral range from the ultraviolet through the near infrared: 1200 to 12,000 Å.

Eight charge-coupled devices (CCDs), four for each camera system, are used to record the images. The four images will be computer processed on the ground and recombined in a mosaic. Each CCD is a solid-state array of silicon detectors and has 800 by 800 picture elements. The use of CCDs in space astronomy was pioneered by JPL and Texas Instruments in conjunction with the Galileo mission to Jupiter ("Charge-coupled Devices in Astronomy," J. Kristian and M. Blouke, *Scientific American* **247,** p. 66, 1982). The virtue of the CCD is that it is an extremely sensitive device with a quantum efficiency well in excess of the eye, photographic film or photomultiplier tubes over a broad spectral range from the ultraviolet to the near infrared. Earth-based telescopes that use CCDs have observed objects fainter than 25th magnitude. A recent, dramatic demonstration of the power of CCDs occurred with the recovery of Halley's Comet by Palomar Observatory last October at apparent magnitude 24.3.

Testing and calibration of the system will be completed by this summer, and then the Wide Field/Planetary Camera will be shipped to the Goddard Space Flight Center for integration with the data system and the other scientific instruments on ST. Following this, the instrument will be tested in ST by the Lockheed Missile and Space Company in California.

In addition to high resolution studies of objects such as galactic centres, the system will be used in an attempt to detect perturbations of nearby stars in a search for Jupiter-sized planets that might be in orbit about them.

The other instruments on ST are: the Faint Object Camera, provided by the European Space Agency; the High-Speed Photometer, built by the University of Wisconsin; the Faint-Object Spectrograph, built by Martin Marietta for the University of California at San Diego; and the High-Resolution Spectrograph, built by Ball Brothers for the Goddard Space Flight Center.

Raymond L. Heacock of JPL is the Acting Manager of the Wide Field/Planetary Camera project, and Professor James A. Westphal of Caltech is the Principal Investigator. Heacock has also served as manager of the Voyager Project and of the new, low-cost Mariner Mark II project which is designing planetary missions for the next decade.

SWEDEN IN SPACE

By Alan D. Farmer

The Swedish government is placing great emphasis on developing "tomorrow's" industries to maintain Sweden's competitiveness in international markets. This includes finding niches in the fast developing space segment. Earth resources and communications are two fields in which they are investing heavily. Though by no means entirely new to space work, Sweden has not yet had a satellite of its own. That will happen, however, in Spring 1984 when a small scientific platform goes cartwheeling into near-polar orbit, courtesy of Ariane. Two years later the large Tele-X experimental communications satellite will lead Sweden and its Nordic partners into the competitive world of space utilisation.

Fighting for Future Prosperity

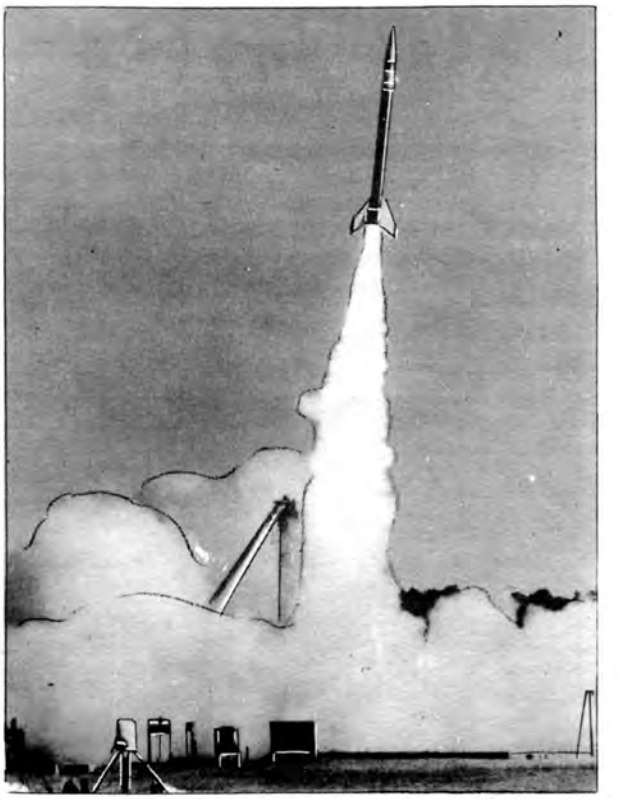
The Swedish economy has many similarities with that of Britain. The traditional, heavier industries are in decline in the face of a world recession and competition from the developing countries. Shipbuilding and the steel industry, for example, as in Britain, are shrinking rapidly. The raw materials markets in wood and iron-ore, the other mainstays of the Swedish economy, are unreliable and volatile. So the Swedes, like other Western countries, have been looking for other ways to stabilise their future prosperity.

The Swedes have always been innovators, especially in technology. They have a disproportionately high share of the world market in manufacturing, and are fighting hard to maintain this edge against increasing competition. A surprisingly large number of international companies are of Swedish origin: Electrolux, Hasselblad, Volvo, Saab-Scania, L. M. Ericsson, Husqvarna and many more. This economic success has meant a high standard of living which the Swedes, understandably, are loathe to let slip.

They have, therefore, pinned their hopes for the future on maintaining their leading position in "new technology" - the high-value, but competitive, top end of the technology market. And because of the way their economy is run, even under a conservative-liberal coalition (and unlike Britain at the moment) it will in large part be government money in research and development on new projects that leads the way.

Space is one area of the "new technology" where the Swedes have found they may be lagging, a position they seem determined to redress. There has for some years been discussions between the Nordic countries (Denmark, Sweden, Norway and Finland) on a Nordic communications satellite, Nordsat, which could offer direct broadcast TV and other services across their national boundaries. Intergovernmental squabbling and the complexities of internal politics have held that up, but the new technology was too valuable to let go by default, so Sweden, Norway and Finland are going ahead in the meantime with Tele-X, an experimental satellite which will try the technology (in the way OTS did for ECS).

Communications is one field Sweden excels in, perhaps because of the relatively vast area it is used to dealing with. Its population of eight million is spread over an area several times that of the British Isles, and as long from North to South as from North Denmark to middle Italy. One of their major industries is the telecommunications giant L. M. Ericsson who supply systems worldwide, including apparatus to British Telecom and whole telephone networks to the Arabs. Companies like L. M. Ericsson realise that long-distance communications is coming to mean more and more satellite technology, and are anxious to get greater involvement. It is not surprising, then, that Sweden's first "commercial" satellite will be a communications carrier.



Saab-Scania of Sweden produces control systems for sounding rockets launched by NASA and Canada, in addition to using them at Esrange.

Sweden's Space Past

Not that Sweden has been idle in the space field previously. No country with such a fine tradition of scientific endeavour could have stayed out of space research. And helped by proximity to the aurorae, which light the winter skies in the north of the country, interest in magnetospheric and ionospheric physics particularly has always been high. The early ESRO (European Space Research Organization) which has been incorporated into ESA (European Space Agency) made something of a speciality of its near-Earth research, and Sweden was one of its early collaborators. ESRO had a rocket launching range, appropriately called ESRANGE, in the north of the country near the town of Kiruna. ESRO/ESA has withdrawn from direct involvement in sounding rockets, but Sweden, through Svenska Rymdbolaget, the Swedish Space Corporation, keeps the range open and, apart from its own experiments, hosts many international "campaigns". (Other European countries continue to help finance the range to keep it open for their use.)

The Germans, in particular, have been flying microgravity research payloads on high-flying rockets in preparation for zero-g research on the Shuttle/Spacelab (as have the Swedes themselves). British launchings have dwindled to very few of late, but the gap seems to have been filled from other sources.

Through ESA, Swedish industry has kept involved at various levels with other space activity: satellite experiments and components etc. Volvo Flygmotor build first and second stage motors for theAriane launcher, Saab-Scania and L. M. Ericsson have built parts of ECS and Marecs, Saab provided an onboard computer for Ariane; and so on. They have been involved

Viking

Saab-Scania Boeing

Payloads:
V1 Electric field
V2 Magnetic field
V3 Particle experiment
V4 Wave experiment
V5 UV images

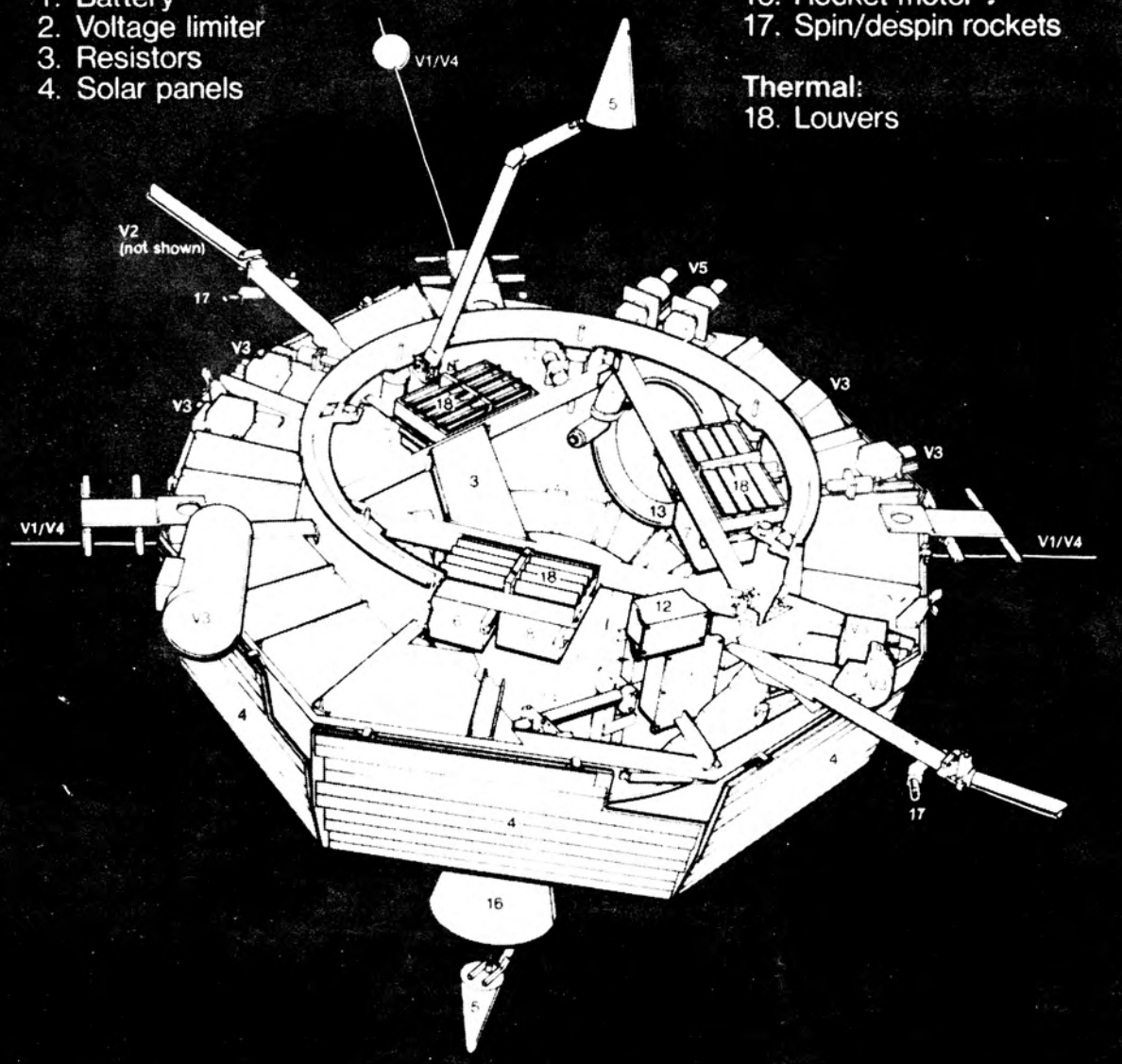
Electrical power:
1. Battery
2. Voltage limiter
3. Resistors
4. Solar panels

Tracking telemetry and communications:
5. Antennas
6. Transponder
7. Decoder
8. Encoder
9. Converter
10. Timer

Attitude control:
11. Earth sensor
12. Control electronics
13. Nutation damper
14. Spin coil
15. Precession coil

Propulsion:
16. Rocket motor
17. Spin/despin rockets

Thermal:
18. Louvers



Sweden in Space/contd.

with Soviet satellites, with an experiment called Promics flying on a craft of the Prognoz series, and a UV spectrograph for solar research on the 1976 Interkosmos 16.

Viking and Kiruna

If ESRANGE were not successful, the Swedish government would probably keep it open anyway for economic and social reasons. It lies close to Kiruna, a town that has suffered more than most from the decline of traditional industries. It is the largest centre for Sweden's iron-ore mining industry, and is being run-down at an alarming rate. The Swedish government to some extent encourages the movement from Kiruna to the better job market in the south, but at the same time is committed to building alternative industries in the area. The parallels with South Wales pit towns are many.

One alternative for Kiruna lies in the development of ESRANGE. A centre for space research, ground stations for satellite tracking and control, data handling centres; none of these *need* to be in large urban centres so why not in Kiruna? With today's communications technology contact can be held with, and data passed to, any other part of the country as quickly from there as anywhere. So ESRANGE will be expanded along those lines, with the Kiruna Geophysical Institute (KGI) gaining valuable status as a research centre. A major development also at ESRANGE will be a new Earth resources image processing centre, a large computer complex for the interpretation and distribution of satellite image data.

As if to demonstrate the commitment to this, the Viking satellite, being built for launch in Spring 1984, is to be controlled from ESRANGE, with data returned there, and much of the scientific work on its payload being carried out by the KGI. ESRANGE has been used for tracking and control on other projects, but this is the first time it will become the managing centre in such a definite way.

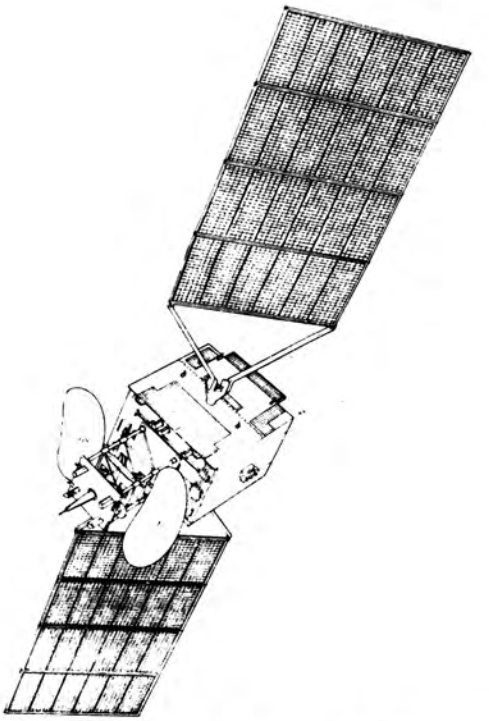
Viking will be a scientific satellite for research into particles and fields in near-Earth and magnetospheric space. Its prime aim is to examine the processes behind the acceleration of the energetic particles causing the discrete aurorae, the injection of ionospheric plasma into the magnetosphere, and the production of intense kilometric radio waves.

Viking will weigh 550 kg and be placed into a 822×15000 km near-polar orbit as a piggyback satellite on the Ariane vehicle carrying the French SPOT remote-sensing satellite. SPOT will be released first after Ariane reaches an 822 km circular orbit at 98.7° inclination (Sun-sychronous). Then Viking will be spun up to stabilise it for release, after which its own small rockets will spin it up further, to around one revolution/second, to prepare for apogee boost burn. Its main motor will then lift its apogee to 15000 km. The spin motors will then decelerate its rotation to a point where the booms can be deployed and, by conservation of momentum, thus slow it further to its final three revs/minute.

In its final configuration Viking "rolls" slowly along its orbital path, its flat-octagon body aligned with its major faces in the orbital plane (like an octagonal wheel) and its 40 m radial wire booms spinning as if to drive it along its orbital path. The main body will be 1.9 m wide and 0.5 m high.

Of the half-tonne launch weight, only 60 kg will be experiments. The four largest radial booms, and two fore and aft, will carry electric field and wave experiments. Two sturdier, shorter radial booms will carry wave and magnetic field experiments, and two further short booms fore and aft will carry the antennae. The sides of the octagon will be covered in solar cells giving the power for the average 50W consumption of the experiments. Maxima of up to 114W will be provided by the batteries. Further experiments include a simple ultraviolet camera for photographing the aurora from space (see *Space Education* **1**, p. 3), together with particle experiments.

Attitude stabilisation will be by nutation damper (a bent tube filled with liquid which damps out small nutational movements by dissipating energy in the "sploshing" of the liquid) and magnetorquers controlled by ground command. The magnetorquer – an electromagnet which reacts against the Earth's magnetic field – will also have a major role in turning the spacecraft over after four months operation. Turnover, to keep the delicate "upper" face of the satellite out of direct sunlight, will take 50 days, and then another four months of operation is planned in the "flipped" position. Design life is given as "80 per cent chance of 8 months", though experimenters hope for a year. The most interesting periods will be when the apogee, two Earth radii out, lies over the polar regions.



The main body of the Tele-X experimental telecommunications satellite (see below).

All data will be transmitted down to Kiruna in 55kbit/s bursts, for processing and further transmission to experimenters in Stockholm and elsewhere. (Experimenters include American and Canadian workers as well as Swedish.)

Satellite prime contractor, under Swedish Space Corporation management, is Saab-Scania, with Boeing as sub-contractor for the platform. Cost is reckoned to be around 106 MSEK (about £10 m).

Tele-X

Tele-X will be a Swedish-Finnish-Norwegian experimental telecommunications satellite with three main goals:

1. Experiment with different services (map-picture transmission, computer-to-computer contact, direct-TV broadcasting, land-mobile, telex);
2. Development of technical know-how;
3. Opening up of new markets for Nordic electronics industries.

The large data transmission capabilities mean a number of applications can be proved:

1. decentralized data processing with direct access to main frame computers;

Sweden in Space/contd.

2. high quality image transmission for e.g. remote newspaper printing, the transmission of aerial pictures, satellite pictures, maps, etc;
3. telephony trunks for transmitting data between areas with digital switching;
4. picture telephones;
5. mobile telex links (long-distance trucks, coaches, trains, etc);
6. the transmission of data, images and texts between corporations and government agencies via telephone links, i.e. "electronic mail".

Swedish industry is anxious about losing out in these areas, especially in view of the fact that in the USA and Europe new corporations have already been founded (e.g. Satellite Business Systems) to exploit the developing market. It is not just the satellite equipment itself; there will be demand for ground segment telecommunications equipment and terrestrial computer hardware that has every chance of exceeding the present market many times over. Improved data transmission capabilities will contribute to speeding up the change-over to digital information processing in all strata of society: Offices will be "computerized" by e.g. interactive text transmission, word processing equipment, computer terminals, and computerized filing systems. In a similar manner, factories will be "computerized" by: numerically-controlled machines, computerized filing of design data, and computer terminals.

Tele-X will be launched by an Ariane 3 from Kourou in 1986. Under the direction of Swedish Space Corporation and Sweden's telecommunications authority, Televerket, definition studies have been carried out by Saab-Scania, L. M. Ericsson and SRA. There will be substantial German and French involvement (see below). Estimated cost is 1250 MSEK (about £115 m) of which 800 MSEK will be the Swedish contribution. Mass at launch will be about 2300 kg and large solar panels will provide the 2500W power consumed. It is a standard three-axis stabilised design ("not unlike a winged clothes closet" as Dagens Nyheter, one of Sweden's national newspapers, put it), 20 m long and 5 m high.

Once in orbit it will locate and turn towards the Earth using infrared sensors. Fine tuning of the antenna pointing (which must be accurate to 5/100 degrees) will be by homing in on a tracker beam from Kiruna. Again Kiruna/ESRANCE will be the main control and command centre.

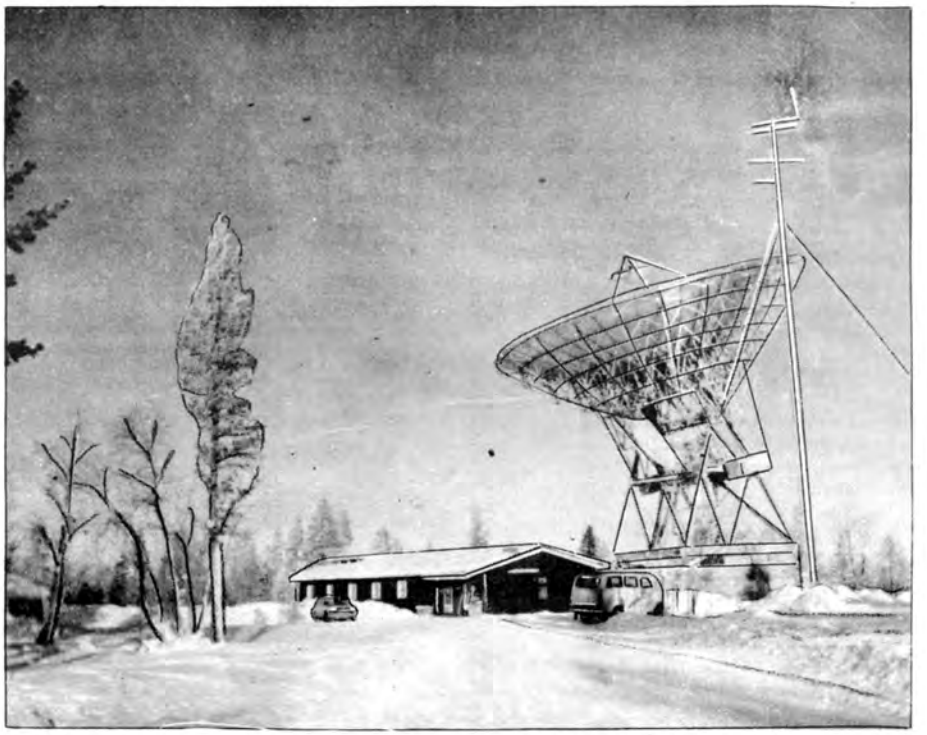
The frequencies to be used, and their associated-experiments are as follows:

1. 14.0–14.25 GHz receive, 12.5–12.75 GHz transmit; 40–100 MHz bandwidth. The large band width is what enables this to be used for fast data transmission. Tests will be carried out up to 64 kbit/s on "special services" for offices: electronic mail (text and facsimile) and computer-to-computer. At 2 Mb/s there will be tests on an "images trunk" service for image transmission, remote printing of newspapers, telephony trunks and computer-to-computer contact.
2. 17.3–18.1 GHz Rx, 11.7–12.5 GHz Tx, 27 MHz bandwidth. This will be used for direct-broadcast TV tests. Two-three TV Channels can be transmitted: voice, image and data in digital form, plus "outside broadcasts". It is possible to expand the service from these tests to provide a mini-Nordsat broadcast service should the political decision be made.
3. 20–30 GHz transmit only. A beacon at this frequency will be used for propagation tests (see also *Space Education* **1**, 3, p. 188).
4. 1.5–1.6 GHz Rx, 1.5–1.6 GHz Tx. Used for "trucksat" concept tests. Will try out interactive exchanges between mobile stations on long-distance lorries, coaches and trains in or near to Europe. The mobile equipment will be a single roof-mounted antenna and a cab unit.

Other Swedish Space Corporation Projects

Much of the Swedish space effort, as with Viking or Tele-X, is or has been organised and managed by SSC, with its HQ in Tritonvägen in the Stockholm suburb of Solna. A state-owned limited corporation under the Ministry of Industry, SSC activities cover the entire range from "think-tank" to the practical applications of advanced technology. It is responsible for the buildup in facilities at ESRANGE. In conjunction with the sounding rocket programme there (which it coordinates, directs and manages) it has helped to develop components for

Volvo Flygmotor produce the first and second stage rocket engines for ESA's Ariane launcher.



The Kiruna UHF receiver, a 30 m dish on an altazimuth mount. The building contains the real-time control system, receiver, control computer and laboratories.

sounding rockets which have been sold to the US and Canada as well as at home, such as a control system for reducing dispersion by up to a factor of 10, a boom deployment system and a standard microgravity payload package. Much of this work was with Saab-Scania. SSC helped the Kiruna Geophysical Institute with its experiment on Prognoz, and Saab-Scania and Jungners with the ultraviolet spectrograph on Interkosmos 16, and will continue to coordinate international collaboration. Work in progress includes development of a Hydrogen-Oxygen advanced rocket engine for a later model Ariane, work on the antenna for the synthetic aperture radar on the French SPOT satellite and cooperation with the French and Germans on communications satellites.

This latter has resulted in an agreement whereby Tele-X will be built around a basic platform developed for French/German satellites, and subsequently Swedish industry will have some work on French and German national projects, and any satellites they subsequently sell to third parties.

SSC, Swedish universities and firms, also have an interest, along with their ESA colleagues, in the Spacelab microgravity processing facilities, and test flights of experiments in sounding rockets have been carried out.

Remote Sensing

With the development of the Kiruna remote sensing analysis centre Sweden is consolidating its interest in the field. Its aim is to have as complete a service, from data capture, through analysis to distribution, as any country in Europe. SSC is developing imaging technology in several areas: sideways looking radar, ultraviolet and infrared imaging, mobile laser systems and pollution measurement and control. Monitoring and controlling pollution of their beloved semi-wild lake-and-forest countryside is something dear to Swedish hearts so it is not perhaps surprising they should be among the leaders in anti-pollution techniques.

Hasselblad, more properly Victor Hasselblad AB of Gothenburg, is a well-known company for manufacturing quality cameras and optical components. It was Hasselblad cameras that the Apollo astronauts took to the Moon. Now Hasselblad is getting involved in analysis of remote-sensing imagery with their "OSIRIS" system. This is a computer-assisted system for selecting from originally photographic material and digitising an image for processing. It has medical and many other uses, but was developed primarily with the Swedish Space Corporation for use on space images.

EISCAT

No description of Swedish involvement in space would be complete without mention of the instrumentation sited in Sweden for studying auroral physics. Sweden has long been host to ionosondes, magnetometers, riometers and the other ground-based paraphernalia of research into the complexities of ionospheric and magnetospheric processes. Recently new, powerful radar systems have joined this work, Doppler radars like the UK/German/Swedish STARE and SABRE projects are just beginning to be proved. But perhaps the most important is EISCAT, the European Incoherent Scatter Scientific Association, with its headquarters in Kiruna. Although established as a Swedish "Stiftelse" (or foundation), EISCAT is an international collaborative project costing over £10 M. At the heart of the system are huge UHF and VHF radar systems with transmitter-receivers in Tromsø, Norway, and UHF receiver antennae in Kiruna, and Sodankylä in Finland. Beside the three Nordic countries, financing comes from Britain, France and Germany.

The incoherent scatter radar technique is perhaps the most flexible remote sounding technique yet found for investigating the plasma of the Earth's mantle. With varying time and height resolutions one can measure electron density, electron and ion temperatures, and plasma drift velocities fairly simply, and several other parameters with somewhat more effort and assumptions. EISCAT will be a major research tool for scientists in Europe throughout the 1980's and 1990's.

T 24

SATELLITE DIGEST – 162

Robert D. Christy

Continued from the February issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

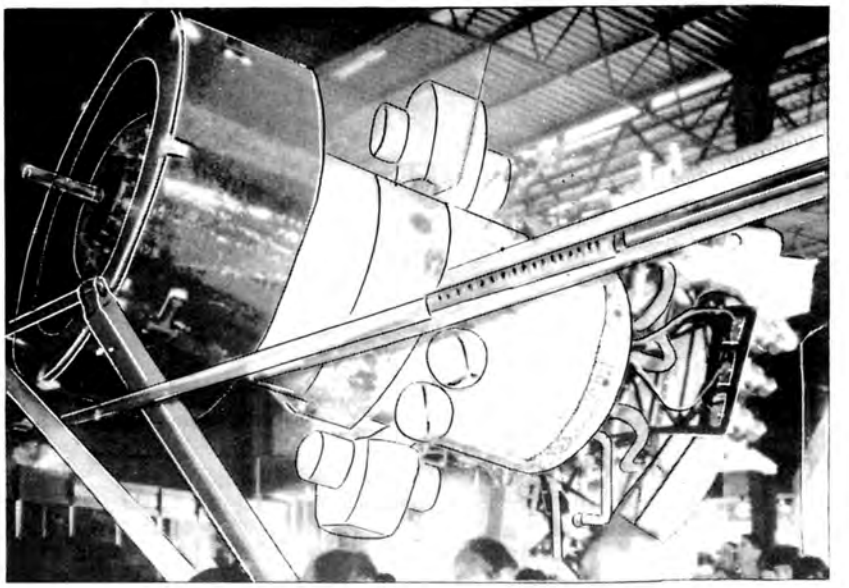
PROGRESS 15 1982-94A, 13558
Launched: 0900*, 18 Sep 1982 from Tyuratam by A-2.
Spacecraft data: Similar in appearance to Soyuz-T except that the re-entry module is replaced by a cone-shaped, non-recoverable compartment for stores. The mass is around 7000 kg.
Mission: To carry consumables and experimental materials to the long-stay crew aboard Salyut 7. Progress 15 docked with Salyut's rear port on 20 Sep, undocked at 1246, 14 Oct and was de-orbited by retro-fire at 1618, 16 Oct. It re-entered over the Pacific Ocean.
Orbit: Initially one of approximately 190×230 km, 89 min, 51.6 deg, later manoeuvred to a transfer orbit of 214×372 km, 89.31 min, 51.64 deg. After docking with Salyut the orbit was 302×326 km, 90.75 min, 51.62 deg.

COSMOS 1409 1982-95A, 13585
Launched: 0630, 22 Sep 1982 from Plesetsk by A-2-e.
Spacecraft data: Possibly based on the Molniya satellites.
Mission: Part of the USSR's missile early warning system.
Orbit: Initially 615×39,361 km, 710.15 min, 63.02 deg, later manoeuvred to 612×39,690 km, 716.69 min, ~~63.08 min~~, 63.08 deg to ensure daily repeats of ground tracks.

COSMOS 1410 1982-96A, 13589
Launched: 0910, 24 Sep 1982 from Plesetsk by F vehicle.
Spacecraft data: Not available.
Mission: Not known, possibly geodetic.
Orbit: 1495×1502 km, 116.00 min, 82.61 deg.

INTELSAT 5 (F-5) 1982-97A, 13595
Launched: 28 Sep 1982 from Eastern Space and Missile Center.
Spacecraft data: Box-shaped spacecraft with antenna array and 16 m span solar panels, mass around 1000 kg.
Mission: US domestic communications.
Orbit: Geostationary.

COSMOS 1411 1982-98A, 13597
Launched: 1200, 30 Sep 1982 from Plesetsk by A-2.



A full-scale model of a Soviet Gorizont communications satellite (Paris Air Show 1981).

N. Kidger

Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6 m, max diameter about 2.4 m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 198×357 km, 90.08 min, 72.86 deg, manoeuvrable.

COSMOS 1412 1982-99A, 13600
Launched: 0000, 2 Oct 1982 from Tyuratam by F-1.
Spacecraft data: Not available but probably several tonnes mass.
Mission: Ocean reconnaissance using nuclear powered radar.
Orbit: 251×266 km, 89.66 min, 65.00 deg.

COSMOS 1413-1415 1982-100A, D&E, 13603, 13605 & 13606.
Launched: 1505, 12 Oct 1982 from Tyuratam by D-1-E + apogee motor.
Spacecraft data: Probably cylindrical with length and diameter about 2 m and mass of each satellite around 700 kg.
Mission: First launch of the USSR's Global Navigation Satellite System.
Orbit: Initially a low, parking one at 51.6 deg then *via* a highly elliptical transfer orbit to approx 19,070×19,080, 673 min, 64.8 deg.

COSMOS 1416 1982-101A, 13611
Launched: 0920, 14 Oct 1982 from Tyuratam by A-2.
Spacecraft data: Similar to Cosmos 1411.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 231×278 km, 89.61 min, 70.36 deg but manoeuvrable.

COSMOS 1417 1982-102A, 13617
Launched: 0600, 19 Oct 1982 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in a drum-shaped solar array. Length and diameter both about 2 m and mass around 700 kg.
Mission: Navigation satellite.
Orbit: 963×1012 km, 104.86 min, 82.97 deg.

MILESTONES

November 1982

16 Shuttle Orbiter *Columbia* lands in California to bring the STS-5 mission to a close.

18 The Salyut 7 cosmonauts, Lebedev and Berezevoi, eject the small Iskra 3 amateur communications satellite into space. It will be controlled by students from centres in Moscow and Kaluga.

22 Shuttle Orbiter *Columbia* is returned to the Kennedy Space Center atop its 747 transport aircraft.

23 Shuttle Orbiter *Challenger* is transferred to the Vehicle Assembly Building at the Kennedy Space Center in preparation for mating with its Boosters and Tank for the STS-6 mission currently scheduled for 24 January.

29 It is reported that a 10 kg meteorite discovered in Antarctica two years ago, and now being analysed at NASA's Johnson Space Center, could have come from Mars. Scientists believe that an angled impact on that planet's surface could have ejected material into space for later capture by Earth. A second sample is thought to have come from the Moon.

30 Shuttle Orbiter *Challenger* is transported to the launch pad for the STS-6 mission.

December 1982

2 A NASA board of enquiry reports its findings on the failure of the two spacesuits that should have been used for space walks during the Shuttle STS-5 mission. Astronaut Lenoir's suit (failed to fully pressurise) had two small parts missing from its pressure regulator, not having been installed during construction. The oxygen circulation fan in Allen's suit failed because of a faulty magnetic sensor, cause yet unknown.

6 Moscow reports that the Venera 13 and 14 main craft, launched in October and November 1981, continue to return information from their orbits around the Sun. Included among their instruments are solar gamma and X-ray detectors. Two probes from these craft landed on Venus in March 1982 and returned the first colour pictures of the surface.

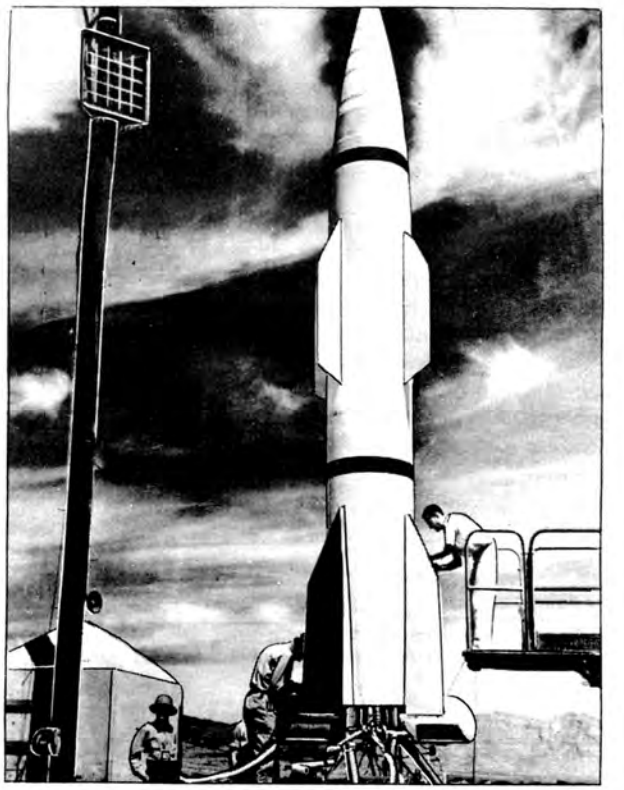
10 Cosmonauts Berezevoi and Lebedev return to Earth, landing in darkness and during a snowstorm, in the Soyuz T-7 craft after a record-breaking 211 days aboard the Salyut 7 space station. They were launched on 12 May 1982.

20 A £34 million contract is signed in Bristol, England between the European Space Agency and British Aerospace for the construction of the Giotto Halley's comet probe.

20 It is reported that NASA is considering equipping Space Shuttle Boosters (which fly up to 46 km before returning to Earth for recovery) with small payloads to conduct upper atmosphere experiments.

DO YOU KNOW?

Can you identify the rocket pictured below? See underneath for the answer.



Answer: No, it's not a German V-2 but the smaller American Hermes rocket flown in the early 1950's to test missile concepts. A further description is given in the Society's book *The Eagle Has Wings*. (Photograph: General Electric).

DO YOU REMEMBER?

25 Years Ago. . .
10 March 1958. Studies begin in the US into the problems of recoverable manned satellites.

20 Years Ago. . .
20 February 1963. John Glenn's *Friendship 7* Mercury capsule is presented to the Smithsonian Institution, one year after the flight.

15 Years Ago. . .
2 March 1968. The Soviets launch the Zond 4 lunar probe, believed to be an unmanned version of the manned Soyuz craft.

10 Years Ago. . .
17 February 1963. NASA's Manned Spacecraft Center in Houston is officially renamed as the Lyndon B. Johnson Space Center in honour of the late President.

5 Years Ago. . .
2 March 1978. Soyuz 28, with cosmonauts Gubarev and Remek aboard, is launched.

D. J. SHAYLER

CORRESPONDENCE

Nothing is New

Sir, The article by Dr. Davies on the Space Telescope in the December 1982 issue (pp.434-441) mentions that Oberth proposed the establishment of an orbital telescope in 1943. In fact, Oberth described such telescopes in 1923 and, in detail, in 1929. He even proposed a segmented mirror telescope; possibly the very first reference for this novel (even today) concept.

Just glancing through Oberth's 1929 classic, I still find that it could be used as a university textbook on astronautics (reentry; fully inertial guidance concepts; trajectory work; engine clustering; communications satellites, Earth observation, large structures – the list is endless.) A pity it has not been published in English or Russian – maybe a publisher will take the hint!

PROF. DR.-ING HARRY RUPPE
Munich

BIBLIOGRAPHY

H. Oberth, "Die Rakete zu den Planetenräumen," (1923)
H. Oberth, "Wege zur Raumschiffahrt," (1929)

SNIPPET

Shades of a Distant Past

Sir, Thank you for a copy of the September/October 1982 *Spaceflight* containing my father's obituary (the late Thomas Ashcroft). It was very thoughtful of you.

I would like to point out "for the record" that he was not really an American member, only having been here 2½ years. As a British member, he was one of the original small group which held its meetings in Liverpool. I imagine he was a member until the move to London. I believe Willy Ley attended one of those early meetings.

Mrs. M. DAVID LEVIN
New York

P. E. Cleator, founder of the BIS, writes:

On p. 37 of the BIS *Journal* for October 1934 (Vol. 1, No. 4) you will find the name T. E. Ashcroft (of Liverpool) heading the list of new members. It is thus more than likely that he was present at the meeting of the Society which Willy Ley attended during February 1935, and it may even be that he appears in the photograph of that occasion which was published in the *Daily Sketch* and the *Daily Dispatch* on the 11th of that month.

BOOK NOTICES

The World in Space
Ed. R. Chipman, Prentice-Hall, 689pp, 1982, £39.95.

This constitutes the proceedings of Unispace '82, held in Vienna with the assistance of many international scientific organizations and distinguished individual contributors.

The volume has been compiled from the series of background papers prepared to assist operations for the Conference, but slightly modified subsequently to incorporate some of the new information which has since become available.

Topics covered correspond to the Conference Agenda and the division of its work among its three main committees. Part 1 includes four chapters which constitute a general view of the state of space science and technology, an assessment of applications and a look at the developments likely to occur within the next decade.

Parts 2 & 3 include five chapters which study some of the key issues dealt with by the Conference and consider social and economic implications flowing from the development of space technology. This includes a chapter on the feasibility and planning of instructional satellites systems, a thorny road if ever there was one. Except for a few experiments, little has happened to fulfil the high hopes of the late 1960's when satellite broadcasting was considered the ideal solution for the educational and developmental problems associated with developing countries.

Part 4 includes three chapters which survey the activities of international organizations concerned with space programmes. The main international agencies involved are Intelsat, Intercosmos, Intersputnik, ESA, Inmarsat and Arabsat. Non-governmental organisations engaged in space activities and specifically mentioned include ICSU, COSPAR and the IAF.

L'Homme dans le Cosmos
P. Kohler, Hachette, 288pp, 1982, 148F.

A quarter of a century after the first Sputnik, the world has seen thousands of satellites, more than 80 manned space flights and about 100 planetary missions. This volume, in French, surveys all these projects and looks towards the future. The 50 tables list astronauts and cosmonauts, space probes, etc.

Handbook of Space Astronomy and Astrophysics
M. V. Zombeck, Cambridge University Press, 326pp, 1982, £18.

The author has compiled tables, graphs, diagrams and formulae to provide a ready-reference working tool for the practising space astronomer and astrophysicist. The material represents a diversified selection because both the astronomer and astrophysicist need to draw on knowledge of atomic physics, nuclear physics, mathematics and the like, in addition to the usual various branches of astronomy.

A total of 20 chapters present data on general astronomy, radio astronomy, infrared, UV, X-Ray and Gamma-Ray astronomy, besides cosmic rays and electromagnetic radiation generally.

Sad to say, the section on Aeronautics and Astronautics is particularly short. It consists of a diagram showing the approximate lifetimes of Earth satellites and six on the Shuttle. These compare so badly with the wealth of material presented in the more astronomical sections that they would have been better omitted.

NOTICES OF MEETINGS

ASTRONOMICAL STUDY COURSE

During its 50th Anniversary Year, the Society is embarking on its most ambitious Study Course yet. Called "Update your Astronomy", the Course, organised in collaboration with Astronomers at the Royal Greenwich Observatory, provides an opportunity for members to learn of the many new and exciting developments in astronomy in recent years.

The fee for the lectures of the second session is £6.00. Individual lectures £1. Registration forms are available from the Executive Secretary.

Meetings currently scheduled for 1983 are as follows:

30 Mar 1983	"Cataclysmic Variables"
6 Apr 1983	"The New La Palma Observatory"
14 Apr 1983	Visit to Royal Greenwich Observatory

Lecture

Title: **SPACE OCEANOGRAPHY**
by Dr. J. O. Thomas
Imperial College, London

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **16 March 1983**, 7.00–9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Study Course

Title: **CATACLYSMIC VARIABLES**
by Dr. D. Jones
Royal Greenwich Observatory

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **30 March 1983**, 7.00–9.00 p.m.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of these Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

Study Course

Title: **THE NEW LA PALMA OBSERVATORY**
by Dr. P. J. Andrews
Royal Greenwich Observatory

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **6 April 1983**, 7.00–9.00 p.m.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of these Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

Study Course

The final meeting in the Astronomical Study Course is an accompanied visit to the Royal Greenwich Observatory at Herstmonceux on **14 April 1983.** Arrival will be at 1.30 p.m. The tour will begin at 2.00 p.m. and last for about two and a half hours, followed by admission to a special exhibition. Arrival by train is not recommended as the nearest station is about five miles away. Further information is available from the Executive Secretary. (Please enclose a stamped addressed envelope).

Technical Forum

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **Friday, 3 June 1983**, 6.30–9.00 p.m., and **Saturday, 4 June 1983**, 10.00 a.m. to 12 noon and 1.30–3.30 p.m.

Continued on back cover

1983 SUBSCRIPTION FEES

Direct Debit Scheme

As from 1 January 1983, our old Bankers Order System was superseded by the Direct Debit Scheme. Introducing the new scheme smoothly makes it essential that all members who formerly paid by Bankers Order complete and submit their Direct Debit slip. Direct Debit slips to become effective from January 1984 are now available from the Executive Secretary on request.

Amounts payable for the calendar year January-December 1983 are as follows:

RATES

Members	Sterling	US Dollars
Under the age of 18 years	£16.00	$35.00
Between 18 and 20	£18.00	$40.00
21 years of age and over	£21.00	$45.00
Associate Fellows	£23.00	$50.00
Fellows	£23.00	$50.00

Age Allowance

A deduction of £2.00 ($5.00) is allowed to members of every grade who are over the age of 65 years on 1 January 1983.

JBIS and *Space Education*

The additional subscription payable for *JBIS*, where required in addition to *Spaceflight*, is £20.00 ($44.00). For *Space Education*, it is £4.00 ($9.00).

Methods of Payment

Europe

(a) Payment should normally be made in sterling with a cheque which shows a UK address, either of the paying Bank or its Agent, where it can be presented for payment.

(b) Cheques drawn in sterling on banks in Europe (including Euro-cheques) must include £2.00 to defray bank charges and collection costs.

(c) Banks which remit directly to the Society must be instructed by members to see that the sum is transmitted *free of deductions*. (Banks frequently impose charges "in transit," so the amount actually received by the Society is insufficient to pay for the subscription thus causing much additional correspondence and trouble both to the members concerned and to the Society).

(d) Remittances from Europe can be made by GIRO: this is the easiest and cheapest method of transferring funds. Our GIRO account number is 53 330 4008.

USA and Canada

(a) Payments by US dollar cheques will be accepted if drawn on a Bank which gives an address in the United States or in the UK. US dollar cheques drawn elsewhere need to be increased by $8.00 to cover bank and collection charges.

(b) US dollar notes are accepted. Other currencies may also be accepted with prior agreement by the Society. Their value must be sufficient to include conversion costs into sterling.

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SPACEFLIGHT

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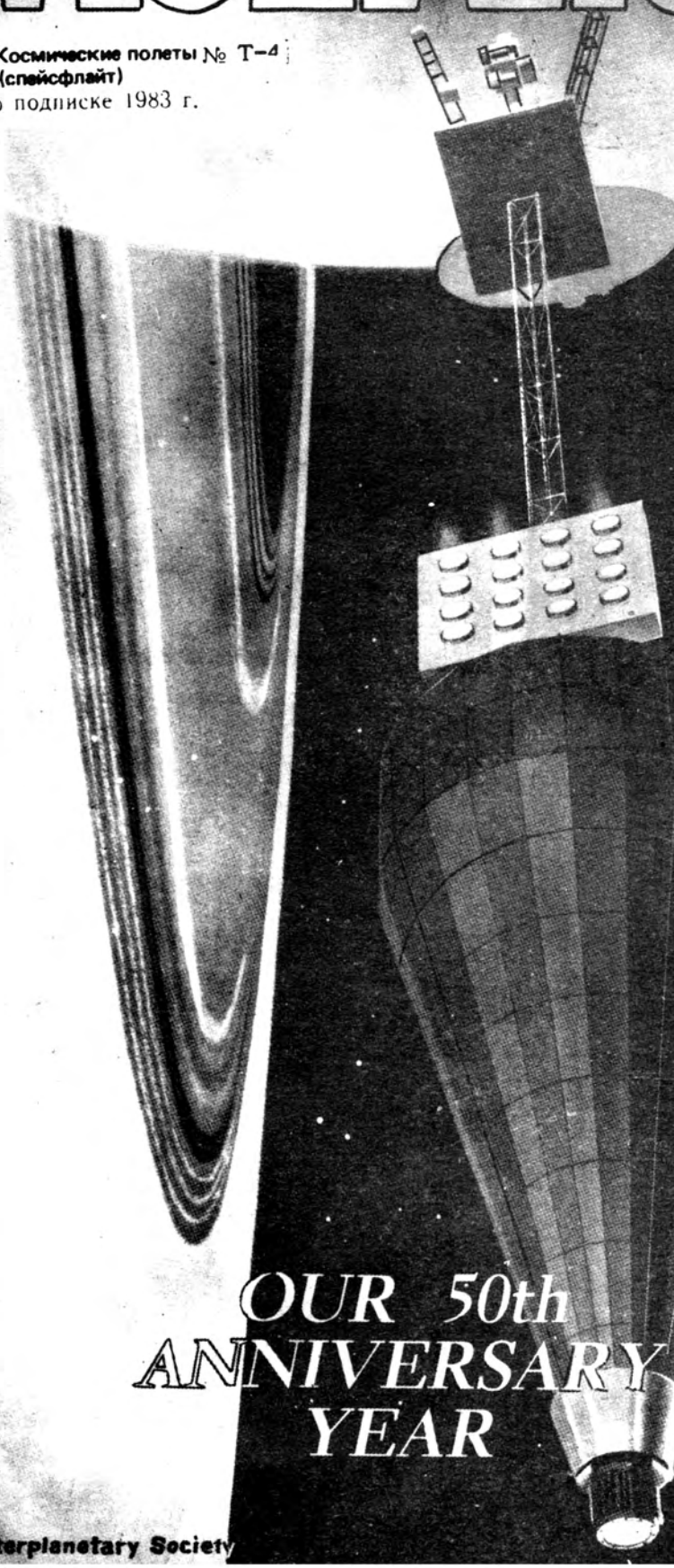

OUR 50th ANNIVERSARY YEAR

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CONTENTS

130 **Up and Down with the Astronauts**
John Bird

132 **Space Platforms**
Staff of NASA

135 **Correspondence**

137 **Milestones**

138 **Space Report**

142 **Space at JPL**
Dr. William I. McLaughlin

146 **Beyond Pluto**
David H. Hinson

149 **The Soviet Space Shuttle**
Gerald L. Borrowman

152 **The Intelsat Giant**

154 **Celebrating Goddard's Centenary**
Frank H. Winter

157 **Rendezvous with Halley's Comet**

158 **Personal Profile**
Mitchell Sharpe

160 **The Private Astronauts are Coming!**
Anne van den Berg

161 **Satellite Handling for the Shuttle**
Gerald L. Borrowman

163 **America's Honoured Astronauts**
Philip Snowdon and Roger Wheeler

170 **Paris in the Autumn**

173 **The 37th Annual General Meeting**

175 **Book Notices**

INTO THE SOLAR SYSTEM

Our regular "Space at JPL" series has received many warm compliments from lay-readers and experts alike. Author Bill McLaughlin is clearly doing a fine job in covering the exciting developments at one of the foremost centres of space activity: the Jet Propulsion Laboratory in California. JPL is well known for its interplanetary probes, the Voyagers and the imminent Galileo, for example, but it also undertakes a startling array of studies for future unmanned missions. Bill intends to take *Spaceflight* readers through the latest concepts and he kicks off this month with a look at the "Saturn Ring Rendezvous" mission, pictured on the cover and briefly described in the caption at the bottom of this page. Later instalments will include a new Neptune probe and a craft for delving into the mysteries of Io's volcanoes. As they say, watch this space.

In the February issue John Bird gave us a glimpse of what it is like to train underwater for space walks. Now, in this issue, he swaps the diving gear for a flight suit to take us high in the atmosphere to experience a few minutes of weightlessness. If NASA goes ahead with plans to take non-astronauts into space aboard the Shuttle then John may some day be writing from first-hand experience!

One of *Spaceflight's* most popular features of a decade ago was the "Personal Profile" series in which space personalities connected with the Society described their work and history. Mitchell Sharpe lights the blue touch paper on "Personal Profile" 1980's style and tells us how he got into the space business. Other personalities will follow suit in later issues.

This is the third issue in the new-style – by next month we hope to complete the change-over. The new covers certainly seem to be appreciated; they look more colourful yet (vital from a budgetary standpoint) they do not involve us in extra expenditure.

Another subscription plea: please if you haven't yet sent in your fees for 1983 then do so without delay. Remember that this year's subscriptions were due in *before* the New Year; late payers involve the Society in considerable expense and time which could be better spent elsewhere. It is also wise to check that you are sending in the right amount!

COVER

This month's "Space at JPL" (pp. 142–145) begins with a look at an exciting new deep-space mission proposal: Saturn Ring Rendezvous. In this artist's concept the spacecraft with its nuclear-electric propulsion unit hangs above the rings of Saturn. This mission would allow close-up inspection of the entire ring system and the vehicle could even lower itself into clear zones to bring material in for onboard study.

NASA/JPL

UP AND DOWN WITH THE ASTRONAUTS

By John Bird

In the February issue of *Spaceflight* the author described what it was like to train underwater for working in space. This month he continues in the same vein, but now the training is done miles above the Earth.

A gentle push on the wall sent us floating slowly through the cabin toward the airlock as I guided astronaut Joe Allen in his bulky spacesuit. We were in a state of weightlessness.

Was I really up in space? Not quite. I was in a NASA KC-135 jet high over the Gulf of Mexico, taking part in a training flight with some of the Space Shuttle astronauts. They were practising the same jobs they had to do during their planned spacewalk in the fifth Shuttle mission (cancelled because of spacesuit problems).

In order to duplicate the weightlessness encountered in space, our jet followed huge curves in the sky like a giant roller coaster. This gave us 30 seconds of weightlessness in which to frolic about like overgrown Peter Pans. But this was followed by half a minute of two "g's", when we weighed twice our normal weight. The whole cycle was repeated 51 times – it is not hard to imagine why the KC-135 is also known as the "vomit comet."

Preparing the aircraft for this flight took a few days. I helped to load the special equipment for inflating the suits, including consoles, a liquid air tank, hoses and wires. All of it had to be securely bolted to the floor to prevent it from floating about during the flight.

Aside from hardware preparation, there was human preparation to be taken care of. First, I went through the US Air Force Class One medical examinations in Houston, then it was on to Oklahoma City for a "pressure chamber flight". This simply involves sitting in a room that looks like the inside of a small aircraft; the air was gradually pumped out, but I was breathing pure oxygen, so I did not notice any change.

"Let's find out what it is like without oxygen", my instructor decided. "Take off your mask, John."

He then had me do an arithmetic test, which was easy at first. After a few minutes my reactions were slower. My fingernails and skin also turned blue.

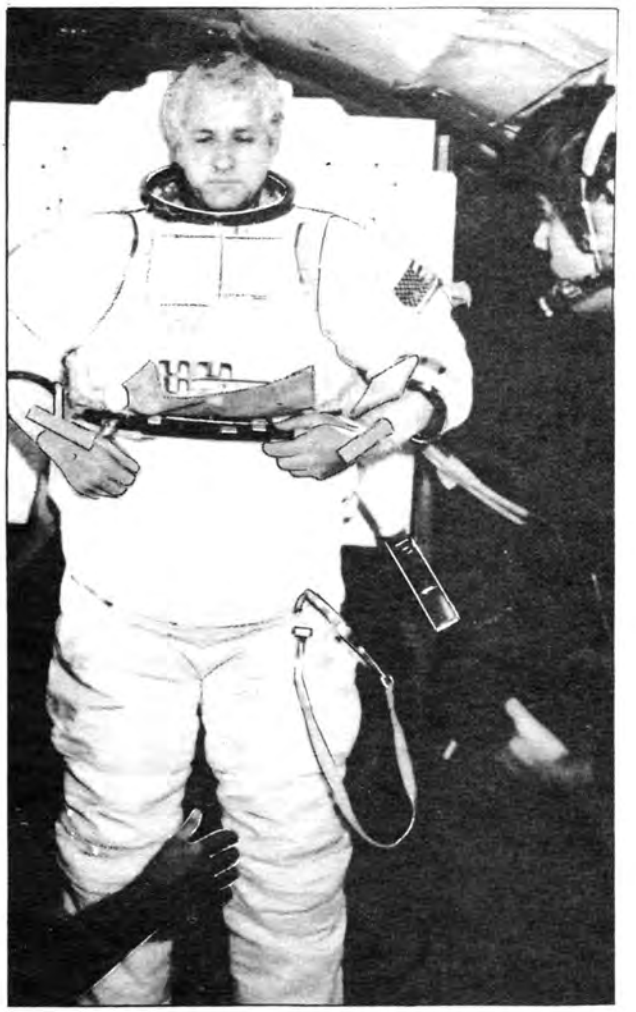
"How do you feel?" my instructor asked. I explained that there was a tingling sensation, and that it seemed warmer. Finally, he told me to put my mask back on. As I started breathing pure oxygen again, I turned from blue to pink in a few seconds.

The final recommended medical preparation was to take an anti-sickness pill. It was an hour before the flight, so I had to decide immediately whether or not to take one. But half of the people I talked to were against it. If I survived without then I would know for future flights. I decided "no"; about half the flight crew did not use them either. As the pilots prepared the 'plane, the rest of us had a briefing. The group included the astronauts, the suit technicians, test conductors, directors and a photographer. It was very informal; everyone was reading newspapers or drinking coffee. Finally, everything was ready. We climbed through a hatch in the bottom of the 'plane, and then bounced along the padded floor to the cluster of seats at the back.

The ascent was like a ride on a school bus. Astronaut Bill Lenoir, on my left, was trying to study, while astronaut Bill Fischer, on my right, was telling us jokes. Meanwhile, the 'plane began to fill with an eerie fog as the pressure dropped.

Suddenly, my weight was increasing. After a few seconds, the jet was climbing steeply, and I could feel my weight changing from 140 kg to nothing. The indicator lights came on and, with a gentle push, I floated out of my seat toward the ceiling. As I floated, the 'plane climbed, then dived, steeply, but I could not feel it. Inside there was no up or down – it was just as easy to work on the ceiling as the floor.

A warning from the crew came over the speakers,



Henry Hartsfield, STS-4 pilot, practises donning a Shuttle EVA suit during a KC-135 flight.

NASA

Author John Bird shows his delight at being weightless while, left, astronauts Lenoir and Allen practise in a mockup of the Shuttle EVA airlock for the STS-5 mission. *Inset*: the airlock's location in the Orbiter.

"Thirty seconds." This meant that "gravity" was about to return and I knew that everything was about to crash to the floor, including myself. I wanted to be down there rather than on the ceiling when weight reappeared. Where was the floor? Not beneath me, and not above. It is easy to forget, especially when it has the same colour and same padding as the walls and the ceiling. Too late, I crashed back to the floor but luckily I landed on the padding and not on top of someone. Feelings of weight started increasing again while everyone waited on the floor for the next "parabola." But I thought I would try walking with twice my normal weight: I took two steps and fell over.

During the next parabola, I decided to look outside and found, to my surprise, the world was upside down. Then I realised *I* was upside down and quickly flipped around. I looked along the fuselage and saw that the entire 'plane was bending. Suddenly, weight returned and I crashed on top of one of the technicians.

After a while, a few of the technicians were not feeling very well, so they were temporarily out of commission. The effects did not bother me, since I was familiar with the much higher forces encountered in fighter aircraft.

My job was to take photographs for NASA but I found it was much more difficult to work in weightlessness than on Earth. One problem was that I had to hang on to something while snapping away to prevent drifting or tumbling. One of the engineers, Tom Grubbs, had a unique solution: he caught hold of me while he held on to the wall with his feet.

Weightlessness is similar to being underwater. One difference is that in the air there is hardly any resistance to motion, so anything that is moving will keep going (a good demonstration of Newton's First Law). For example, I tried putting my camera into a spin. It carried on while floating in front of me without slowing down. If I pushed off a wall to move across the cabin I could not change course along the way.

"Two more", the crew announced. Since the flight was nearly over, everyone stopped working to enjoy floating freely – most of the technicians had spent the whole flight strapped to the floor. On the last parabola, the 'plane flew a curve that produces "negative gravity". This means up was down and down was up. For a few seconds we were all on the ceiling, and when the 'plane returned to regular weightlessness there was mass confusion with people, equipment, random pieces of padding and wire floating everywhere.

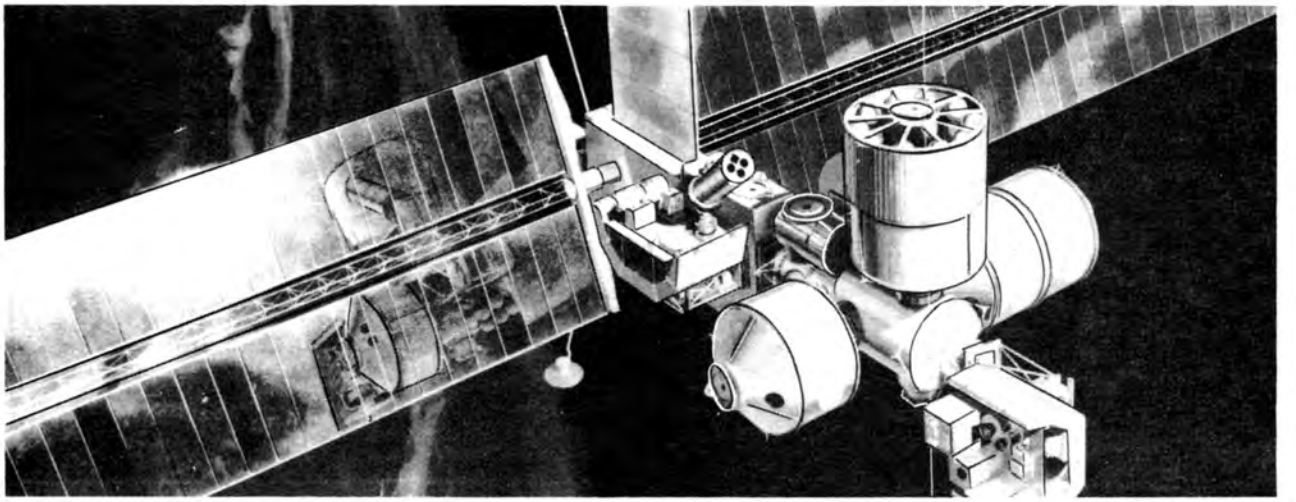
For the trip back, Tom strapped me into an extra seat in the cockpit so I could watch the landing from the pilots' point of view. After landing, one of the technicians asked the pilot when he was going back up.

"This afternoon", he replied.

"I don't envy you".

SPACE PLATFORMS

By the Staff of NASA



Introduction

The beginning of Space Shuttle operations has opened new doors to the use of space. For years, scientists have relied upon the ..stly method of individual, expendable satellites to perform on-orbit research. Now, however, the Shuttle offers routine two-way access to space.

For some time, work has been underway to develop the first Shuttle-based science and Earth applications research system: Spacelab. This joint project of NASA and the European Space Agency is a manned laboratory to be carried aloft in the payload bay of the Shuttle. It features a mix of habitable modules and U-shaped "pallets," which are aluminium structures not unlike airline cargo containers. On these pallets, groups of experiment equipment can be prepackaged for placement in the Shuttle's cargo bay.

Spacelab, set to become operational in September 1983, will represent a major advance in science and applications efforts in space. But, as good as it is, it has some limitations that the experimenters would like to overcome. The laboratory's current maximum mission duration of about nine days is limited chiefly by the amount of power the Shuttle fuel cells can generate in orbit. The fact that all experiments must be carried inside the Shuttle cargo bay limits Spacelab's pointing capability. When one instrument is observing a particular star, the entire Shuttle must be oriented toward deep space. This would prevent an Earth-observing experiment from functioning at the same time.

NASA has been working on an answer to these and other limitations. It will come in the form of a composite system that combines Spacelab with other equipment in an evolutionary way designed to meet growing needs with incremental hardware growth. The first step in this evolutionary process is expected to be a module known as the Space Platform.

1987: Year of the First Step

The Space Platform is a 26,000 lb (12,000 kg) module capable, among other things, of generating many kilowatts of solar power for indefinite periods of time. Far more power, in fact, and for much longer times, than the Shuttle can provide to experiments that operate from its cargo bay. Because of these platform advantages, experiments could be removed from the cargo bay and attached to special berthing ports on the platform. In this way, long-duration experimentation could go on long after the Shuttle returned to Earth. Drawing energy from the Space Platform, these untended payloads could remain on orbit for six months or more. Periodically, the Shuttle would return to change the old experiment packages for new ones, and to maintain the platform itself.

An inherent capability exists to support Spacelab if the platform were to dock with the laboratory and thereby extend the length of Spacelab's missions from about a week to approximately a month. The Space Platform would satisfy a wide range of science and applications objectives in the areas of high-energy astrophysics, astronomy, solar physics and atmospheric science.

NASA proposes to "park" such a system in low Earth orbit by 1987.

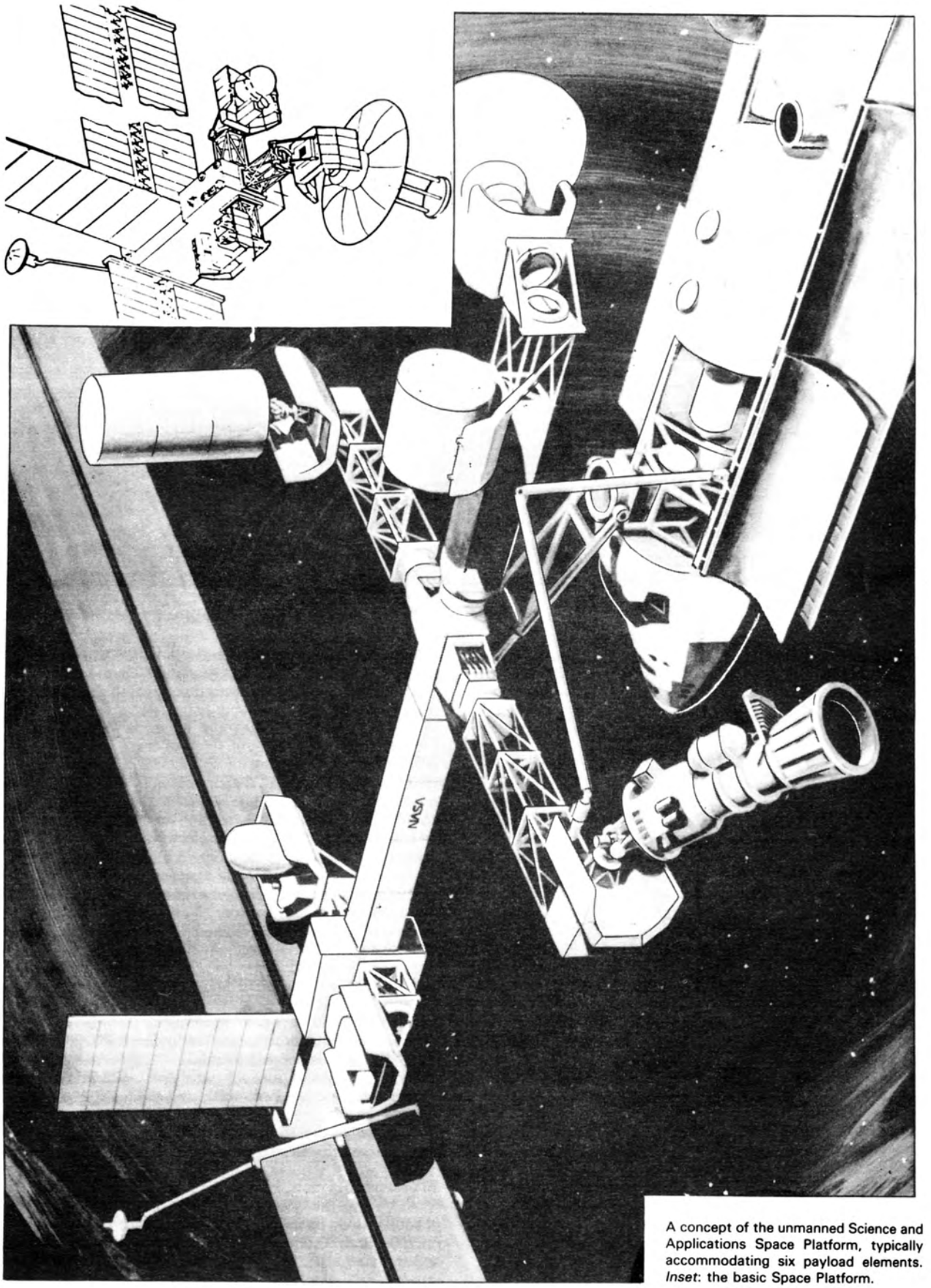
Basic Features

The primary structure is a rectangular frame divided into three sections. The forward section contains most of the electrical and thermal control subsystems equipment. The central section contains most of the attitude control, communications, and data handling subsystems equipment. The aft section contains three berthing ports for payloads and a fourth for the Shuttle. These ports are located to permit easy access by the Shuttle's Remote Manipulator Arm, a robotic mechanism used to remove payloads from the cargo bay and install them at the ports on the platform.

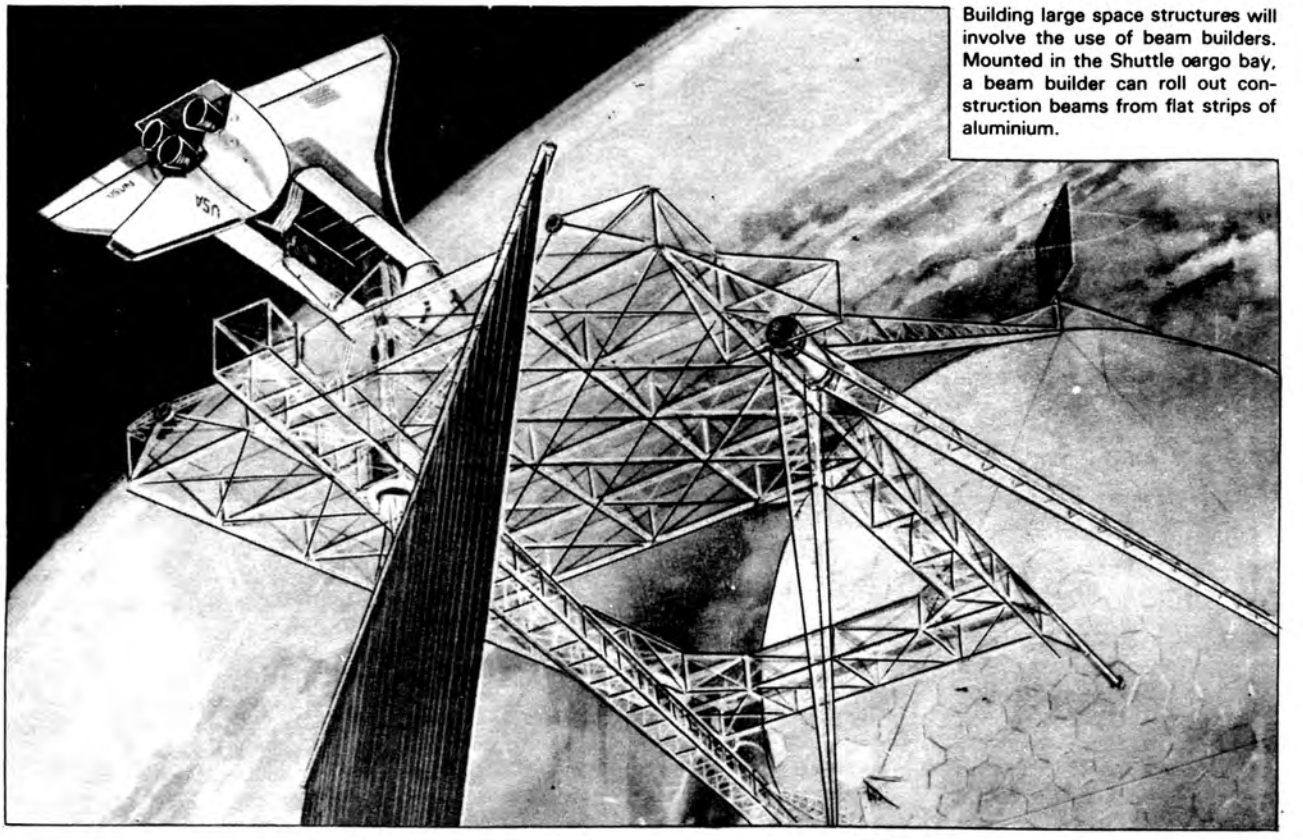
The platform would gather its energy from the Sun by using wing-like solar arrays. Folded into the cargo bay of the Shuttle, the arrays would be deployed upon reaching orbit. Batteries in the platform would store the electricity so that power could be furnished even on the "night" side of the orbit. Present designs call for a power capability of about 12 kilowatts, but as payloads are later added, the demand for power will increase. These demands would be met by increasing the size of the solar arrays.

The platform would, of course, provide more than power to attached pallets. Control moment gyros would provide stabilization and attitude control, and a reboost capability would keep the platform and its payloads at the proper orbital altitude. The platform would also provide heat dissipation, using a pumped coolant loop and a deployable radiator, and it would provide communications and high data rate telemetry. These features eliminate the need to send into orbit, as has been done in the past, separate support systems for individual satellites.

Another important feature of the Space Platform is that each of the pallets would be capable of individually pointing its instruments for its own scientific purpose without interfering with neighbouring payloads. One experiment package, for example, could be focused on the Sun; at an adjacent berthing port, an instrument could be studying the Earth in a natural resource observation; and at yet another pallet, an X-ray telescope could be monitoring distant nebulae. Such a capability eliminates the more costly approach of launching individual satellites to cope with the various instrument pointing needs of the scientific community.



A concept of the unmanned Science and Applications Space Platform, typically accommodating six payload elements. *Inset*: the basic Space Platform.



Building large space structures will involve the use of beam builders. Mounted in the Shuttle cargo bay, a beam builder can roll out construction beams from flat strips of aluminium.

Advanced Platforms

Once the basic Space Platform has been placed in orbit and successfully used by payloads left behind to free-fly (function independently of the Shuttle) the next step in evolutionary growth would be taken in the years that follow. That step would be the Science and Applications Space Platform.

The SASP is not profoundly different from the Space Platform. It is, in fact, merely the natural outgrowth from the basic design described above.

Although some studies indicate a need to replicate the basic design of the Space Platform in various sizes and for placement in different orbits, analyses also show a need to expand any or all of the basic platforms to the next higher stage by adding T-shaped extension structures to provide additional payload berthing ports and to increase pallet spacing. A typical SASP system, for example, would accommodate six payload elements, although even that number could probably be surpassed. Its need for power would increase, of course, and the solar array wings would be enlarged from the proposed initial 12-kilowatt capability to probably 25 kilowatts for the expanded structure. In addition to the increased power, the original platform would continue to provide its other supporting features to the SASP, such as attitude control and heat rejection.

Manned Platforms

In the evolution of the Space Platform from its basic free-flying design to its expanded unmanned version, the next step is clear: that with the addition of a life-supporting module attached to a berthing port, a manned capability would be possible. The Science and Applications Manned Space Platform, or SAMSP, would be used for such missions as life science, materials processing experiments and Sun-Earth observations which can benefit from human interaction.

Among the areas in which the SAMSP would be most valuable would be its benefit to Earth medicine. Since extended zero-gravity exposure provokes a unique combination of abnormalities in the heart and bone tissue, research on the body's responses to zero-g will fill voids in our knowledge caused by the limited studies of environments of one-g and higher. Such studies in space will contribute to developing treatments for cardiovascular and skeletal abnormalities here on Earth. The manufacture in a weightless environment of extremely pure pharmaceuticals would be a boon to medicine, and the manufacture of materials with unique electrical or mechanical properties could yield new products.

The current concept of the manned system provides for a platform with a habitability/experiment, or H/E, module that would support a crew of four. The module is an expanded version of the Spacelab, designed for logistics resupply by the Shuttle every 90 days. Resupply flights for replacing expendables - such as food, water, oxygen, nitrogen, and clothing - could be shared with other Shuttle missions. Basic resources like power, heat rejection, communications, attitude control and station keeping would continue to be provided by the original Space Platform that preceded the SASP. A pressurized adapter - a cylindrical extension located between the basic platform and the H/E module - would provide for the structural attachment between the Shuttle and the SAMSP and would allow for crew transfer. An air lock mounted to the pressurized adapter would provide for both routine and emergency extravehicular activity. In an emergency, the air lock and pressurized adapter would serve as a "safe haven," with a 21-day supply of expendables, until a rescue could be accomplished.

As the platform continued to evolve, more life-support modules would be added. The four-man capability would grow to eight and beyond. At that point, the temporary manned aspects of the platform would be replaced by a permanent manned presence.

CORRESPONDENCE

The Problems of SETI

Sir, "The Decline and Fall of SETI" chronicled by Robert Sheaffer in the December 1982 *Spaceflight* constitutes an intriguing series of episodes in the saga of humankind's exploration of space. I had always thought that the search for evidence of extraterrestrial intelligence was the prime motivation behind space exploration; somehow the more immediately materialistic objectives focused on by our Congressmen have never held the same fascination for me. I was fortunate to have learned in advance of the SETI Advisory Panel Meeting in Washington, D.C., in May 1976 and to have attended it as a non-participating member of the public. Having lunch with other observers, including Robert Sheaffer, provided the only open opportunity for exchanging ideas.

Senator Proxmire's arguments included in Robert Sheaffer's article seem to me to call for a response. Here are my own reactions:

1. Agreed there is not a scintilla of evidence that life exists beyond our Solar System. That was the point of SETI: a practical approach to a preliminary search for such evidence within the framework of current technology and resources.

2. Agreed that communication over great distances could be meaningless. But SETI had progressed from the concept of communication to concentration on the search, in that SETI supplanted CETI. To bracket SETI with the outmoded CETI concept indicates a lack of comprehension of the objectives of the programme.

Scientists work best at what they enjoy. NASA, with University support, is the natural Agency for research directed toward the search for evidence of extraterrestrial intelligence, and it is hard to believe that the United States Government will long continue to permit this effort to lie dormant. Now, if only the Soviet Union would come up with something. . . .

STUART GREENWOOD
Maryland, USA

Solar Power Satellites

Sir, Congratulations to the organisers of Space '82. Having recently returned from several years working in Japan, I could not have asked for a better reintroduction to the Society's activities.

There was little mention by the various speakers of Japan's activities in space. But she has an expanding space programme, backed by a strong industrial base, as well as intense public interest. We shall be hearing much more of it.

Nowhere did this thought strike me more forcibly than during Raefe Shelton's presentation on the Solar Power Satellite. Europe may need the SPS more than America: but Japan needs it even more than Europe, for she has far less access to other sources of energy. Unlike Britain, Japan has no oil and little coal of her own, and therefore has to import most of her energy, which makes her intensely vulnerable to events beyond her control. Japan has therefore been searching urgently for the means to trade technological and financial muscle for reliable long-term energy supplies. She has, for instance, looked hard at the possibilities of investing in the opening up of Siberia, but the political problems are formidable and Soviet reliability questionable. Another avenue is to move heavily into the development of undersea technology, although again it is not under Japanese seas that the oil appears to lie.

Japan is a natural for the SPS, which at long last offers her an energy source under her own control. From her own abilities she could replace much of the technical contribution that the Americans might otherwise furnish, and she could certainly match them on the financial side.

A peculiarity of Japan is the popular aversion to nuclear alternatives, deriving from memories of Hiroshima. This may of course fade with time, but meanwhile remains a factor against one of SPS's competitors. The "nuclear allergy" has, however, developed a strong environmental lobby in Japan. This might well work in SPS's favour, but it could also backfire if public imagination seized upon the currently unknown environmental impact of the microwave beam from SPS. I suggest that this area is in particular need of clearing up.

I should like to see the SPS developed tripartitely between Europe, America and Japan, but I believe that Japan would be able and willing to replace either partner if necessary. She might incidentally be joined in a smaller way by Korea and Singapore, who in 20 years time are likely to have similar energy problems combined with the ability to contribute money and skill to the project.

E. A. S. LIDDERDALE
London

SNIPPETS

A Fine Job, Indeed

Sir, I would like to put into writing my thanks and appreciation for the organisation and thought that went into every aspect of Space '82 at Brighton. Both the calibre of the speakers and the quality of the papers presented were very high and, not only did I learn a lot, I enjoyed learning it! In fact, my enthusiasm was rekindled to such an extent that I have since joined an Astronomy evening class!

As a more tangible expression of my thanks, please accept the enclosed money towards the BIS Development Fund.

SALLY LORD
Bedford

Sir, The seaside took on a new delight for me when I attended Space '82 at Brighton. The conference centre made an excellent venue and I was most impressed by the smooth and quick registration, which only took two minutes!

The organisers had arranged an ideal length for the

lectures, which was just right to maintain interest, and all the speakers were to be congratulated for keeping to their allotted times. The range of topics had something for everybody. I look forward to Space '84 with great anticipation.

CYRIL HORSFORD

Sir, Congratulations to all concerned with Space '82. It was an outstanding event; the most interesting space conference that I have had the pleasure to attend.

DR. W.I. McLAUGHLIN
California

Sir, I was very sorry I missed Space '82 but I saw an extremely good and long report of it on "South Today" (BBC Southern TV on 15 November). It included exceedingly informative interviews with three of the US Speakers.

L. R. SHEPHERD

Apollo Memories

Sir, As one privileged to see the launch of Apollo 17 I was interested to read the tenth anniversary article in the January issue. The plaque on the Lunar Module also includes the words: "May the spirit of peace in which we came be reflected in the lives of all Mankind". It seems a pity not to quote this excellent sentiment.

F. R. SMITH
Kent

It Gets Lonely, Sometimes. . .

Sir, There are not many other BIS members here in my area in Alaska, but I found myself in the midst of a great many fellow BIS members last August when I represented the Governor of the State of Alaska at Unispace '82 in Vienna, Austria. I made a point of wearing my BIS badge when I gave my paper there on lunar mining, and several very prominent colleagues, upon seeing it, came up to identify themselves as fellow members. We all made quite a club.

EDWARD B. KIKER
Alaska

It's Appreciated

Sir, I am a new member of the BIS, and I want to take this opportunity to compliment you on your quick processing of my membership application. Although overseas, your response is faster than that of many US companies in these matters.

This fine service, along with the excellent quality of *Spaceflight*, make me happy to be a member. I look forward to many years as a member of the BIS.

MARK SHELHAMER
Massachusetts, USA

. . . and again . . .

Sir, I must surely speak for the majority of the BIS membership when I say that *Spaceflight* is always a delight to receive. It is informative and visually exciting and accurately reflects the competence of those who produce it.

BIIL DILLON
Beds.

SOCIETY SOUVENIRS

The Society produces a wide and varied range of items for sale, all of high quality. Why not buy a T-shirt or badge for yourself, or treat a friend? Remember, you'll not only support our Development Appeal but also provide valuable advertising for the Society.

T-shirts

Available in BLUE or WHITE with large BIS logo; chest sizes 32–34, 34–36, 38–40 and 42–44 in. Cost is £3.50 in the UK or £4.00 ($9.00) abroad, post free.

Sweatshirts

High quality BLUE sweatshirts with BIS logo. Chest sizes 32–34, 34–36 and 42–44 in. available. This is your last chance: our stock will not be replaced. Cost: £7 UK, £7.50 ($16.00) abroad, post free.

Badges

Three types of badges are available, all with the Society logo:

- **Enamel lapel badges (£1 UK, $3 abroad)**
- **Cloth blazer badges (£1 UK, $3 abroad)**
- **Metal car badge (£3 UK, $8 abroad)**

Ties

A dark BLUE tie with the BIS logo visible just below the knot. Cost £6 UK, £6.50 ($15) abroad, post free.

Binders

The ideal way of keeping your magazines in perfect condition. *Spaceflight* binders carry *BLUE* covers, those for *JBIS* are *GREEN*. Gold lettering on the spine identifies the magazine, volume number and year. Cost: £5 ($11 abroad) each. Note: *JBIS* binder fit post-1976 volumes.

When ordering please be sure to specify exactly *what you require (size, colour, quantity etc). All orders to The British Interplanetary Society, 27/29 South Lambeth Rd, London SW8 1SZ, England.*

MILESTONES

December 1982

17 West Germany announces that ESA astronaut Wubbo Ockels will fly as payload specialist aboard their Spacelab D1 mission in 1985. Ockels is presently a backup for this September's Spacelab 1 mission.

18 Shuttle Orbiter *Challenger* three main engines are fired in a 20 sec test on the launch pad in preparation for the STS-6 flight on 27 January. This is the first time that all three have been ignited together. There is concern over a concentration of hydrogen gas in the aft end after the firing.

20 The first of the US Air Force's Block 5D-2 polar-orbiting weather satellites is launched from Vandenberg Air Force Base in California by an Atlas E booster. The 750 kg craft has a design lifetime of 3 years.

27 Apollo 13 astronaut John Swigert dies from bone marrow cancer. He was to have been sworn in to the US Congress on 3 January.

28 Kosmos 1402, a nuclear-powered radar ocean surveillance satellite, fails to boost its fission reactor into a high orbit. This satellite type normally breaks up into sections at the end of operations, with the 45 kg of uranium being boosted into a safe orbit some 960 km high. The reactor section could now strike anywhere between 65 degrees north and south latitudes, probably towards the end of next month.

30 The £160 million contract for L-Sat, the large European communications satellite, is signed between ESA and British Aerospace. L-Sat 1 will be launched in 1986.

January 1983

10 The STS-6 Shuttle mission is postponed until late February because engineers are still searching for the cause of potentially explosive hydrogen gas build-up at the rear of *Challenger*. A second main engine test firing (see 18 December entry above) will now be held to look for further clues. The STS-7 and -8 launch dates in April and July may now be affected.

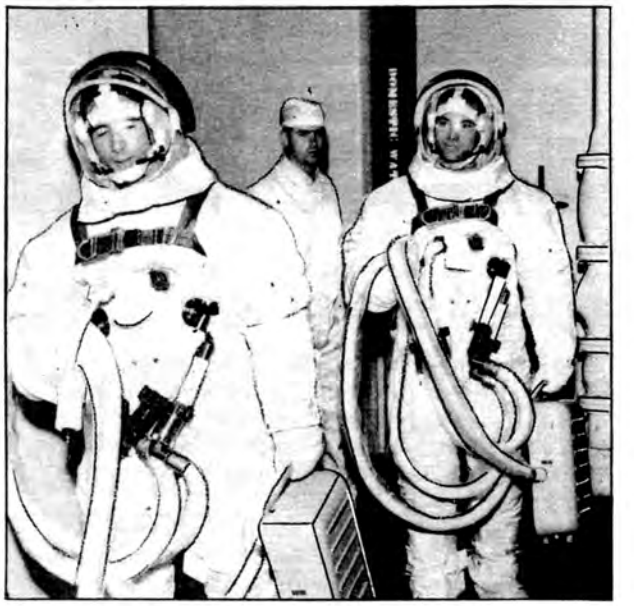
15 *Soviet Weekly* notes that Vladimir Shatalov, head of cosmonaut training, disclosed in a Moscow press conference last week that one of the two Indians now in training will fly to the Salyut 7 space station sometime in the first half of next year.

17 The Ariane L6 launch might be delayed until May or June as work continues on stage 3 engine modifications. The L5 vehicle failed last September.

19 The International Maritime Satellite Organisation begins using part of the Intelsat 5 F-5 capacity for maritime communications over the Indian Ocean.

DO YOU KNOW?

The picture below shows two astronauts setting out to test the Apollo Lunar Module in a vacuum chamber. The man in front is clearly identifiable as Jim Irwin, who eventually went to the Moon with Apollo 15 in 1971. But who is the man following Irwin? (Answer below the picture.)



Answer: He is astronaut John Bull, chosen for the space programme at the same time as Irwin, in 1966. Bull never flew in space; he had to leave NASA in 1968 because of a rare medical condition.

DO YOU REMEMBER?

25 Years Ago . . .

17 March 1958. The second US satellite, Vanguard 1, is launched from Cape Canaveral.

2 April 1958. President Eisenhower calls for the creation of a civilian space agency (NASA came into being on 1 October 1958).

20 Years Ago . . .

28 March 1964. Saturn SA-4 is launched on the fourth successful test of the Saturn I first stage.

15 Years Ago . . .

27 March 1968. Yuri Gagarin, the first man in space, is killed in an aircrash while training for a flight in the Soyuz programme.

7 April 1968. The Soviets launch the lunar orbiting Luna 14 spacecraft.

10 Years Ago . . .

3 April 1973. The Salyut 2 spacecraft is launched but tumbling makes it uninhabitable. It reenters on 28 May.

6 April 1973. Pioneer 11 is launched as the second probe to Jupiter and Saturn.

5 Years Ago . . .

31 March 1978. The Soviets launch Cosmos 1000 in a series which began in 1962.

D. J. SHAYLER

ESA LOOKS TO THE FUTURE

On 16 December the ESA Scientific Advisory bodies recommended that five of the 20 new scientific mission proposals recently received should be studied further with a view to considering them as candidate missions in the Agency's Scientific Programme in the late 1980's or early 1990's.

Groups of experts evaluated the quality of the expected results from each mission, the suitability and technical feasibility of the instrumentation, the interest the proposal is likely to arouse throughout the scientific community at large, the relationship of the proposals with national or international programmes and, finally, the possibility of carrying out the mission as a collaborative venture with other agencies.

ESA has decided that the following proposals should be evaluated further:

FIRST
Far Infra Red and Sub-millimeter Space Telescope, for the study of galactic, extra-galactic and cosmological emissions. Payload mass would be about 2,000 kg; the main instrument an 8 m deployable telescope.

XMM
X-ray Multi-Mirror, designed to carry out deep X-ray surveys of galaxies and clusters as well as high resolution X-ray imaging and spectroscopy. The 2,750 kg payload consists of 27 grazing incidence imaging telescopes.

SOHO
Solar High-Resolution Observatory, for the investigation of the dynamics and of the mass loss of the solar outer atmosphere. The 470 kg payload would include a grazing incidence spectrometer and a stigmatic normal incidence spectrometer, EUV imaging telescopes, and a UV and white light coronograph.

CLUSTER
A mission to study in three dimensions plasma turbulence and small-scale structure in the Earth's magnetosphere. This mission requires a main spacecraft with a 56 kg payload, plus three companion spacecraft, each with a 22 kg payload. This cluster of four satellites is carefully controlled in position as it passes through the many different regions of plasma surrounding the Earth.

AGORA
Asteroid Gravity, Optical and Radar Analysis, designed to study the properties of three main belt asteroids, e.g. regolith thickness, shape (volume), mineralogy, topography and mass. This mission has a model payload of between 100 and 230 kg consisting of a wide angle camera, an infrared spectrometer, a radar altimeter and a number of experiments for cruise science; a high resolution camera could also be included.

Besides making recommendations for these five proposals, ESA's scientific advisory bodies, prompted by the mission proposal for a VLBI (Very Long Baseline Interferometry) radio astronomy observatory in space (QUASAT), also recommended that the Executive begins discussions with other agencies on setting up an international VLBI system.

In connection with a proposal for a Saturn Orbiter and Titan probe (CASSINI), they felt the Executive should begin negotiations with NASA on a cooperative approach.

SHUTTLE UPPER STAGE

NASA is holding discussions with a private company, Orbital Systems Corp., on the commercial development of a new upper stage for the Space Shuttle.

The new stage would be used to propel payloads into orbits beyond the Shuttle's capability and would complement the present Payload Assist Module, the Inertial Upper Stage, and the wide-bodied Centaur (under development).

1983 AT THE CAPE

A combination of Shuttle and expendable vehicle launches will assure ample work for the Kennedy Space Center in 1983: five Shuttles, seven Deltas and two Atlas Centaurs.

Shuttle *Challenger* made its debut with STS-6. The second launch will take up Anik-C (Telesat, Canada), Palapa-B (Indonesia), SPAS-1 (West Germany) and OSTA-2 (NASA experiments). *Challenger's* third mission will involve the first night Shuttle launch this summer. The orbiter will carry TDRS-B and INSAT 1-B (India). *Columbia* will return to duty in September

with Spacelab 1, while *Challenger* will round out the Shuttle year with a Defense satellite identified only as DOD 84-1 in November.

Other 1983 launches are:

Feb	Intelsat V	Atlas Centaur
Mar	RCA-F	Delta
Apr	GOES-F	Delta
Jun	Galaxy-A	Delta
Jul	Telstar 3A	Delta
Aug	RCA-G	Delta
Sep	Galaxy-B	Delta
Oct	NATO IIID	Delta
Oct	Intelsat VA	Atlas Centaur

Hughes Communications enters the burgeoning field of private communications satellites with the Galaxy series while American Telephone & Telegraph returns to the scene it pioneered with Telstar. GOES is a geostationary weather satellite.

An eighth Delta launched the IRAS observatory from California in late January.

SHUTTLE MISSION CHANGES

Norman Thagard and William Thornton have been added to the crews of Shuttle flights STS-7 and STS-8, respectively. Both medical doctors, they will help to study the problems of space sickness, (which has affected about half of the astronauts on Shuttle missions). The planned EVA on STS-5 was postponed because of Lenoir's ill-health.

Thagard will join STS-7 Commander Bob Crippen, Pilot Fred Hauck, and Mission Specialists John Fabian and Sally Ride. The six-day mission is scheduled for launch in May or June.

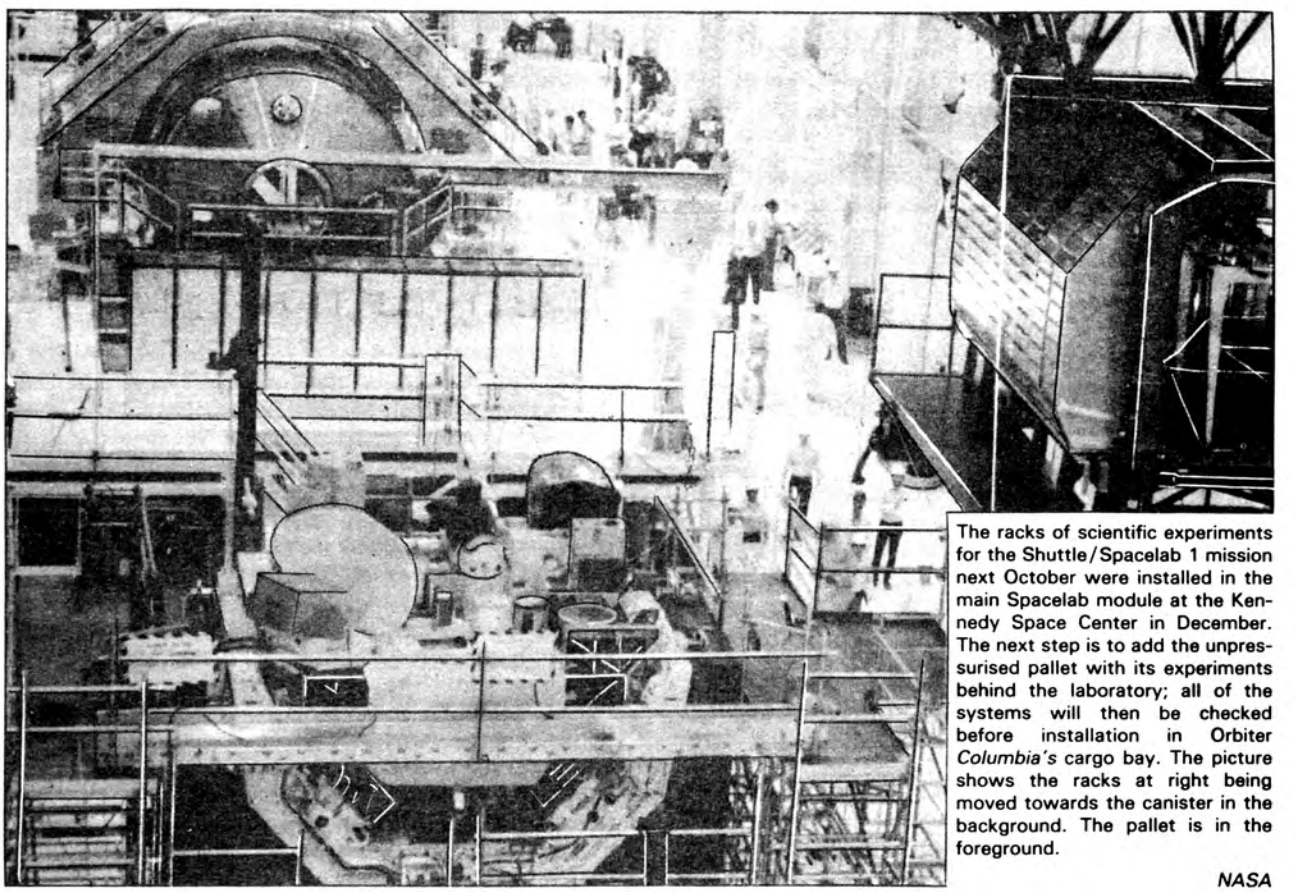
Thornton will accompany STS-8 Commander Dick Truly, Pilot Dan Brandenstein, and Mission Specialists Dale Gardner and Guion Bluford for the four-day mission this summer.

"NEW" LAUNCH PLATFORM

The launch of STS-6 not only marked the first flight of the orbiter *Challenger*, it was also the first time that Mobile Launcher Platform 2 had been used since the last Saturn 5 lifted off nearly a decade ago.

The hulking, battleship-grey structure is not one of the more glamorous pieces of hardware in the space business, but it has had an illustrious career. It is one of three mobile launchers designed and built for the Apollo manned lunar missions, transporting the rockets out to the pad and then serving as launch base. It saw service for Apollo 6 (an unmanned orbital test flight), the Apollo 9 manned orbital mission, and the Apollo 12 and Apollo 14 lunar landings. It was last used for Apollo in the May 1973 launch of the Skylab space station.

It has returned to operational duty for the Shuttle



The racks of scientific experiments for the Shuttle/Spacelab 1 mission next October were installed in the main Spacelab module at the Kennedy Space Center in December. The next step is to add the unpressurised pallet with its experiments behind the laboratory; all of the systems will then be checked before installation in Orbiter *Columbia's* cargo bay. The picture shows the racks at right being moved towards the canister in the background. The pallet is in the foreground.

NASA

following a five-year project involving major modifications. Technicians were busy stacking the Solid Rocket Boosters for STS-6 on the platform before the engineers involved with the conversion project even had a chance to celebrate its completion. The main job was to remove the tall umbilical tower, since the Shuttle now has one permanently at the launch pad.

Work will begin soon on modifications to the third platform which presently sits in a parking space north of the Vehicle Assembly Building. It will be ready for Shuttle duty in 1986.

AUSTRALIAN ASTRONAUT

Australia has announced plans to fly their own payload specialist astronaut on the Space Shuttle. He or she will fly on one of two 1985 Shuttle missions on which space has been reserved for communications satellites owned by Aussat, operator of Australia's national satellite system.

The announcement came in response to an offer made recently by NASA Administrator James Beggs. The offer was based on NASA's policy of allowing payload sponsors to fly their own personnel. Australia is the first country to formally announce an acceptance.

The Australian Department of Science and Technology will be responsible for the selection of the astronauts and other arrangements, in association with Aussat. The two satellites will be used for direct television broadcast, voice, data and public telephone services to continental Australia and off-shore territories.

GERMAN SPACELAB MISSION

The Federal German Minister for Science and Technology announced on 17 December 1982 that Germany had nominated the two ESA scientist-astronauts, Wubbo Ockels and Ulf Merbold, as prime and back-up Payload Specialists respectively, on the German Spacelab Mission D1. For this mission, scheduled for June 1985, the two men will reverse the roles they will have on the first Spacelab mission this September in which Merbold will be on-board specialist and Ockels his back-up.

Two national candidates, Dr. F. Furrer and Dr. E. W. Messerschmid were named for the second Payload Specialist post.

VIKING SATELLITE

Early in December 1982 the Boeing Aerospace Company completed the platform for Viking, Sweden's first satellite. Viking is to be launched in 1984 by Ariane to study the Earth's magnetosphere, concentrating on the aurora borealis. The aurora is of particular interest to higher latitude countries because it disturbs radio communications, writes Gerald Borrowman.

Viking will consist of a platform with the experiments mounted on a deck above. A solid rocket motor will provide the impulse necessary to position the satellite in a polar eliptical orbit. Power for the experiments will be supplied by solar cells around the satellite. To hold down costs, Boeing used off-the-shelf components wherever possible.

Since Viking is to be launched with another satellite, it resembles a small, flat, octagonal disc so that it can fit into the space available.

The engineering challenge was awarded to Boeing because of its experience in building the US Air Force's S-3 scientific satellites which made similar studies, but in a lower orbit and at different latitudes.

ATMOSPHERIC RESEARCH

A new technique for mapping gases in the Earth's atmosphere has proved to be accurate when compared to studies made from the ground. The Measurement of Pollution from Satellites (MAPS) experiment flown aboard the second Shuttle mission during November 1981 charted concentrations of gases around the world.

A gas filter radiometer produced measurements of the carbon monoxide mixing ratio in the middle, upper and lower troposphere. This method is simpler and much less expensive than previous gas chromatograph devices. Although the experiment produced concentration maps only of carbon monoxide, the primary objective was to verify the use of this cheaper technique as an orbital pollution monitor in general.

The analysis so far indicates significant concentrations of middle troposphere carbon monoxide mixing over the North Atlantic, the Mediterranean Sea and the Middle East.

NASA plans to refly this experiment on the 17th Shuttle mission, scheduled for the summer of 1984, to study seasonal variations in the total abundance and regional distribution of carbon monoxide within the atmosphere.

EUROPE IN SPACE

The Vice President of the European Commission told the European Parliament last December that the European Community would integrate space technology into its research and development policy from 1984. Given the availability of greater financial resources, a European satellite could be put at the disposal of the developing countries to meet their particular needs.

These comments resulted from a Parliamentary Question tabled by Madron Seligman, Vice Chairman of the Committee of Energy and Research and Member of the European Parliament for West Sussex. Mr. Seligman said "The efforts of the European Space Agency and of European firms in Eurospace will receive a new impulse from political and financial support at the European level. It is of the first importance that the European Community should complement national contributions to ESA's programmes, and eventually provide greater political and economic cohesion so that long term projects can be tackled with confidence."

THE ASTRONAUTS OF STS-7

Four of the STS-7 crew during emergency rescue training. In light coveralls, left to right, they are: Bob Crippen, Fred Hauck (in vehicle), Sally Ride and John Fabian. STS-7 will carry two commercial communications satellites and scientific payloads for NASA and W. Germany.

NASA

Robert Laurel Crippen

STS-7 will be Bob Crippen's second flight into space, having been pilot of STS-1. He will also be the first man to fly two different Shuttles.

Crippen has been an astronaut since 1969 (see *Space Education*, Vol. 1, July 1981, p. 30) and was selected for STS-7 in April 1982.

Frederick Hamilton Hauck

Frederick Hauck was born on 11 April 1941 in Longbeach, California. He earned a B.S. in physics from Tufts University in 1962, followed by an M.S. in nuclear engineering from MIT in 1966. He entered the US Navy in 1962 and between 1964 and 1966 attended USN post graduate school, studying mathematics, physics and Russian; flight training was undertaken between 1966 and 1968.

Hauck was selected by NASA in January 1978 and completed the 12 months training programme before being named as support crew member for STS-1. He served as backup CapCom for the re-entry phase of that mission and also as re-entry CapCom for STS-2. He was named for STS-7 in April 1982.

Sally Kristen Ride

Sally Ride was born on 26 May 1951 in Los Angeles. She received a B.A. in English and a B.S. in physics from Stanford University in 1973, followed by an M.S. in physics in 1975 and a Ph.D. in 1978. Her research at Stanford included work in experimental general relativity and X-ray astrophysics.

Ride was selected as a Mission Specialist in January 1978. She acted as backup orbit CapCom for STS-2 and prime orbit CapCom for STS-3. She was named as an MS for STS-7 in April 1982.

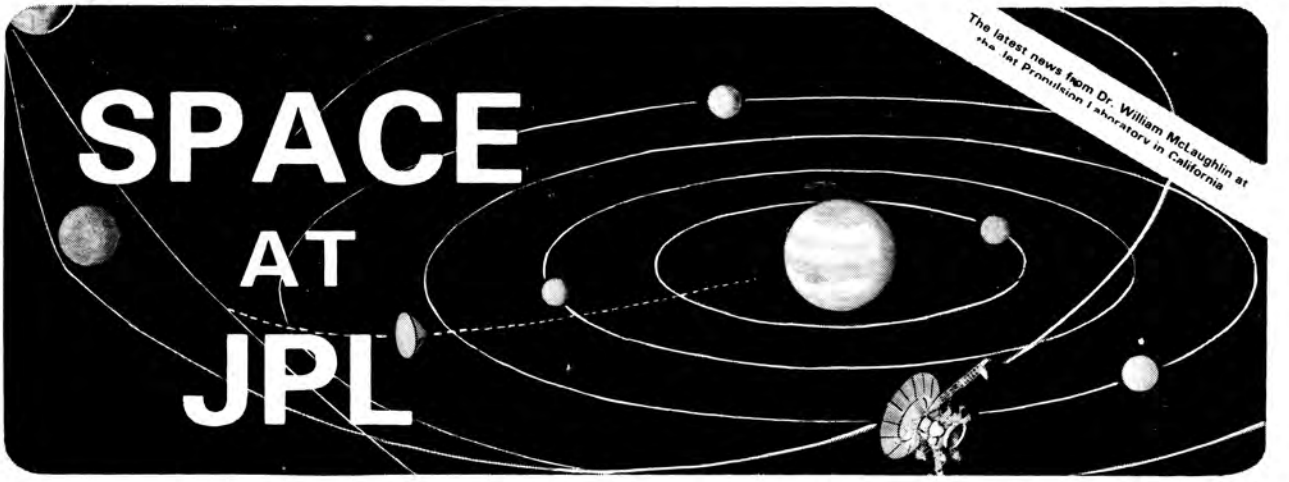
John McCreary Fabian

The second Mission Specialist for STS-7 will be John Fabian. Born on 28 January 1939 in Goosecreek, Texas, he was awarded a B.S. in mechanical engineering from Washington State University in 1962. This was followed by an M.S. in aerospace engineering from the Air Force Institute of Technology in 1964 and a Ph.D. in aeronautics and astronautics from the University of Washington in 1974. Fabian entered the Air Force in 1962 and saw combat action in South-East Asia. Between 1974 and 1978 he was assistant professor of aeronautics at the USAF Academy in Colorado. He was selected by NASA in January 1978.

Norman Earl Thagard

Thagard, selected as a Group 8 astronaut in 1978, was added to the STS-7 crew last December specifically to study the problems of space sickness. As a qualified doctor, he has worked in that field during his Shuttle training.

D. J. SHAYLER



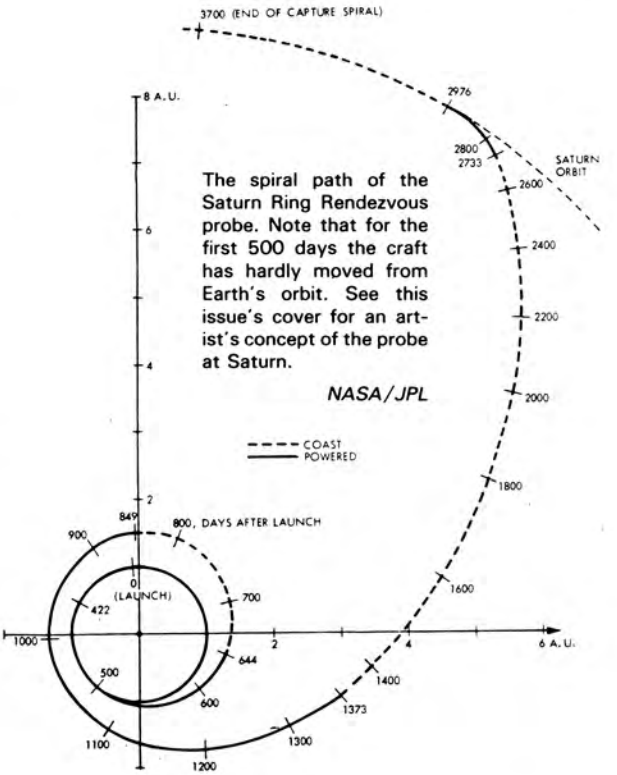
PLANETARY MISSION CONCEPTS

Planetary missions can be classified in many ways. One method describes how close the mission is to coming into existence. In the category of highest certainty lies a "flight project," for which a project approval document, or PAD as NASA calls it, has been issued. An example is the 1986 Galileo mission to Jupiter. A "development flight project" is next, and it represents a concerted effort to define and develop a project to the stage where it will become approved with a PAD. Current examples are the Venus Radar Mapper (VRM) ("Space at JPL" in the December 1982 issue), or the TOPEX mission described below. The two remaining categories are somewhat arbitrary but could be labelled "studies" and "advanced-concept studies," with the latter at the bottom of the ladder.

Kerry Nock supervises the Advanced Projects group in the Mission Design section at JPL, and recently he talked to *Spaceflight* about some of his group's advanced-concept studies. One of these missions is outlined briefly here, with others to follow in future installments of "Space at JPL."

The Voyager and Pioneer missions began the detailed study of the rings of Saturn, and a Saturn orbiter may be approved in the future, similar to Galileo with Jupiter. However, the most definitive study of this fascinating swarm of particles needs a spacecraft positioned very close to the rings, or even in them, to make *in situ* measurements of their structure and composition. One such advanced-concept mission is the "Saturn Ring Rendezvous."

This uses a nuclear-powered electric propulsion system (from a low Earth orbit, reached by the Shuttle) which continually expels mercury ions from the spacecraft, resulting in an ever-widening spiral trajectory until Saturn is encountered after more than eight years of flight. This spiral path contrasts with the usual elliptical orbit which is used to transfer from planet to planet after brief pushes provided by chemical engines such as those onboard the Shuttle/Centaur launch system. At the time the spacecraft begins its outward spiral from Earth it weighs about 17,000 kg with about 10,000 kg of mercury propellant. After one minute of thrusting the vehicle has moved only 0.3 m and has increased its speed by only 0.01 mps, yet the steady push will drive this spacecraft across hundreds of millions of kilometres to Saturn. On reaching its target, the spacecraft is made to spiral into the planet.



The spiral path of the Saturn Ring Rendezvous probe. Note that for the first 500 days the craft has hardly moved from Earth's orbit. See this issue's cover for an artist's concept of the probe at Saturn.

NASA/JPL

The value of the electricpropulsion system shows itself as the probe approaches Saturn's outermost ring. Here, the spacecraft rotates so that its thrust is partially directed toward the plane of the rings, which boosts it slightly above the ring system while it continues to spiral into the planet. From this advantageous position, only 1 to 20 km above the ring plane, the entire radial span of the rings can be observed by instruments as they move from the outermost to the innermost ring.

Coming across particle-free regions, the probe could be lowered gently into the rings themselves by adjusting the direction of thrust, achieving true rendezvous. Scientific examination of ring material taken onboard would be possible by means of chemical analyses, mass spectroscopy and even electron microscopy.

Such a rendezvous mission using nuclear electric propulsion was first described by W. C. Wells and M. J. Price, then of the IIT Research Institute, in 1972.

Other advanced concepts which will be reviewed in

future issues include a mission to Neptune (other than the planned 1989 encounter by Voyager 2), an aircraft to fly in the Martian atmosphere, and a mission to study the volcanoes of the Jovian satellite Io at close range.

SATELLITE ALTIMETRY

Gravity is the weakest of the four basic forces of nature, being less potent than electromagnetism and the strong and weak nuclear forces. Usually its effects only show themselves when large amounts of matter are piled together to form planets or stars.

However, there do exist more delicate gravitational phenomena. For example, "resonance" effects build up from many small impulses over long periods, in one case resulting in gaps in the rings of Saturn.

Another is the tendency of water to form a surface which lies closely along levels of equal gravitational potential. This surface is called the marine geoid. The precision altimeter flown onboard JPL's Seasat mission collected data related to the shape of the Earth's marine geoid and the currents and waves which distort it. These data have recently been processed to show the topographic relief for most of the world's oceans for the period from 7 July to 10 October 1978 (see the March *Spaceflight*, p. 107).

The results are impressive and show the influence of geological structures on the ocean floor upon the shape of the surface. The images supply new and detailed information about the oceans, particularly in the southern hemisphere which has been surveyed less than the northern.

Seasat, launched on 28 June 1978, carried five sensors into an 800 km orbit, inclined at 108° to the Earth's equator. These sensors (radar altimeter, scatterometer to measure sea surface winds, visible and infrared radiometer, synthetic aperture radar (SAR), and scanning microwave radiometer to measure sea surface temperatures) returned a large amount of data until the satellite was silenced by a short circuit in its power system in October 1978.

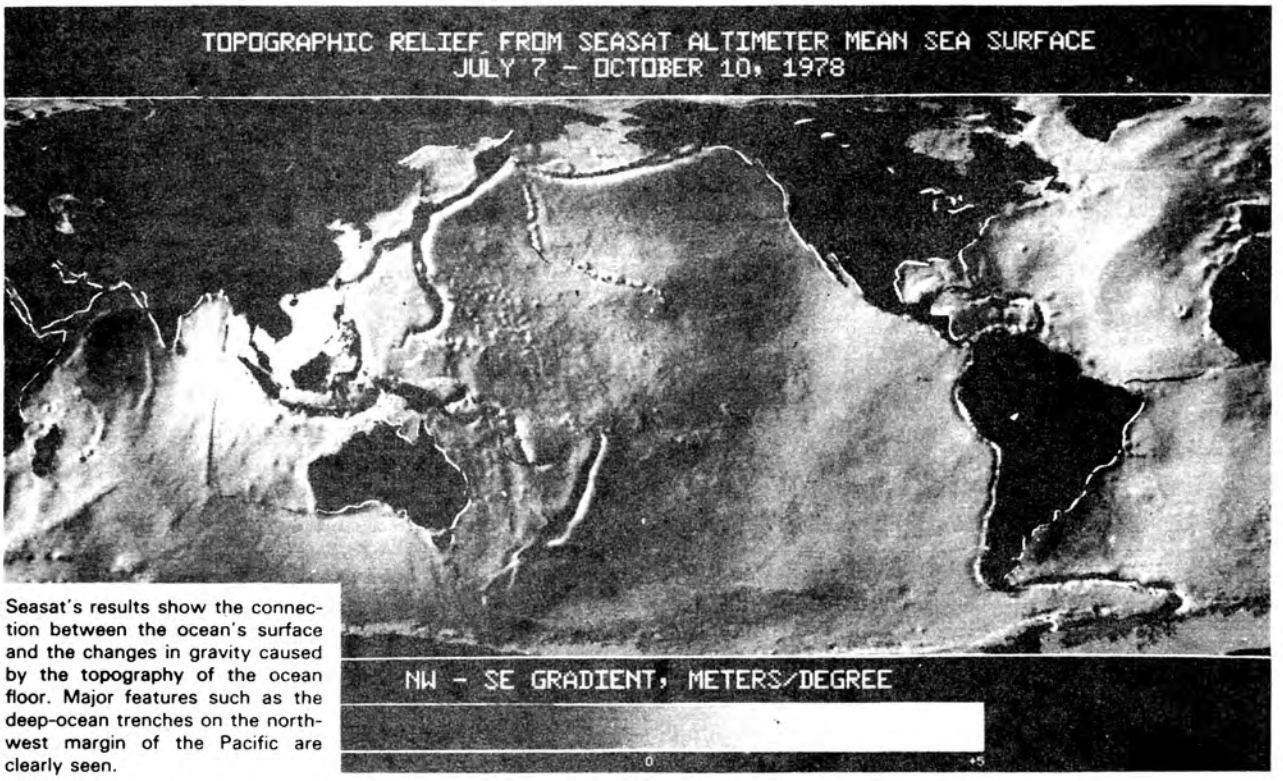
The scientific community has invested a great deal of effort in interpreting the data. The *Journal of Geophysical Research* devoted an entire issue to some of the Seasat results in 1982 and is planning a second.

The SAR experiment has provided what are probably the best-known of the Seasat results and seems to have assured the continued use of this type of remote sensing: SIR-A and SIR-B onboard the Shuttle and possible applications for mapping the surfaces of Venus, Mars, and Titan, if these planetary endeavours can be funded.

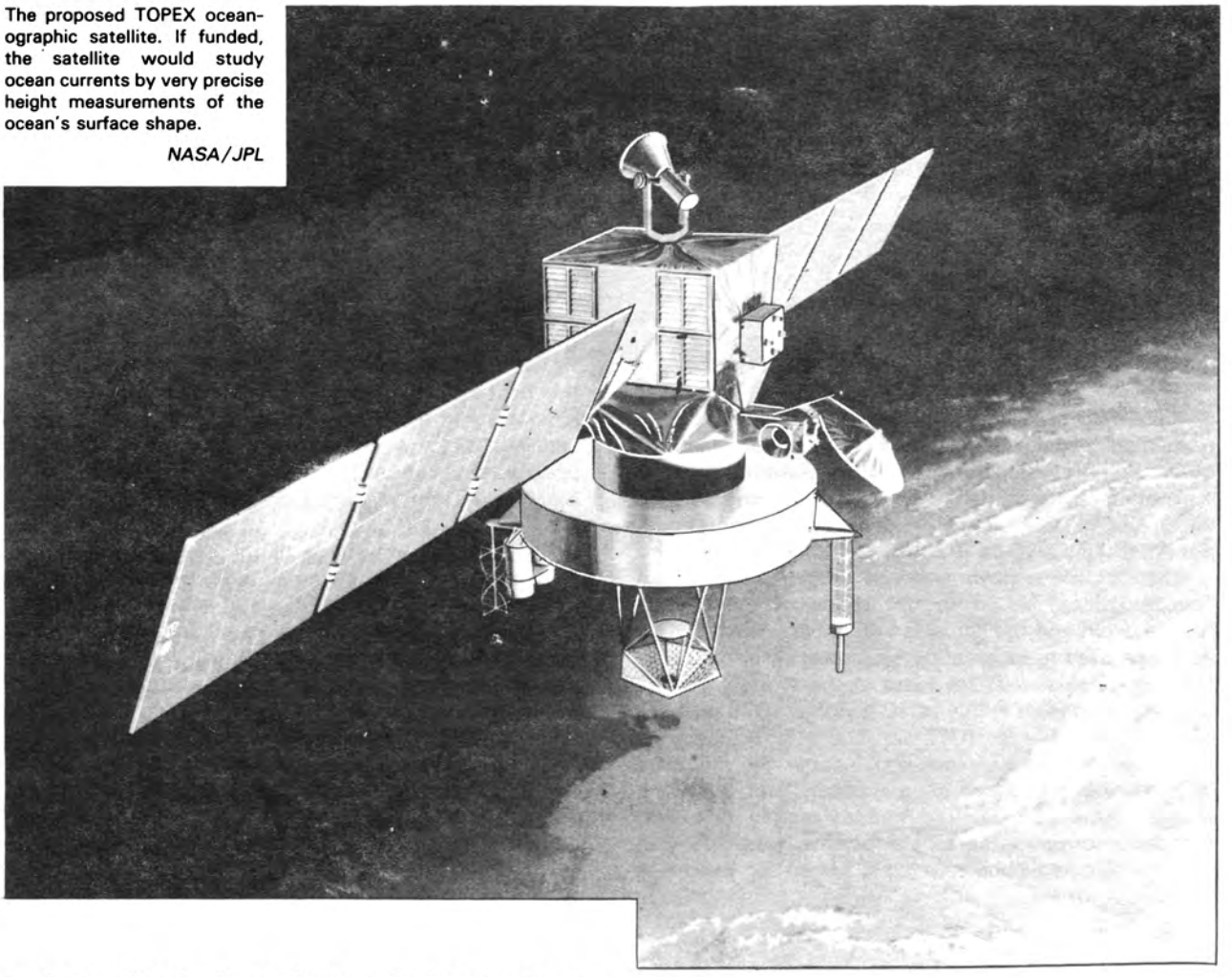
By producing an image of the average sea surface from the altimetry data, that instrument has also assumed a rather dramatic role in geophysical studies.

The altimeter was a "short-pulse, nadir-viewing" instrument with a precision of better than 10 cm. The extreme precision means that the corrupting influences of the atmosphere, for example, had to be carefully taken into account and that the Seasat orbit had to be reconstructed very carefully; otherwise the precision of the altimeter would have been wasted. An accuracy of about 1.5 m in the height of the orbit was achieved globally, which is a better result than for any other comparable satellite.

A possible follow-on mission to Seasat is being



Seasat's results show the connection between the ocean's surface and the changes in gravity caused by the topography of the ocean floor. Major features such as the deep-ocean trenches on the northwest margin of the Pacific are clearly seen.



The proposed TOPEX oceanographic satellite. If funded, the satellite would study ocean currents by very precise height measurements of the ocean's surface shape.

NASA/JPL

studied at JPL: the Ocean Topography Experiment, or TOPEX, satellite. If funded, TOPEX would be launched late in this decade into a 1,300 km orbit at an inclination of 65°. The main purpose would be to study the general circulation of the oceans by precision altimeter measurements. Ocean currents cause a rise in the ocean surface above the marine geoid; for example, the Gulf Stream lifts the water level by about 2 m over a large section of the ocean.

The orbital height of 1,300 km would reduce the effects of atmospheric drag to a minimum and slightly reduce (compared to Seasat) the influence of errors in the model of the Earth's gravitational field. The ground track of the satellite would be designed to provide coverage of the same spot on the ocean every 10 days, thereby allowing studies of ocean variability even where the gravity field is poorly mapped. The mission would last 3 to 5 years.

The TOPEX altimeter is planned to have a precision of 1 to 2 cm and a second instrument, a microwave radiometer, would be carried to make measurements of the radiation emitted from water vapour in the atmosphere between the satellite and the ocean. From these measurements, corrections to the altimetric data could be made which would compensate for the presence of the vapour.

Charles A. Yamarone, Jr. of JPL manages the TOPEX development flight project.

CHRONICLING THE LABORATORY

Clayton R. Koppes, an assistant professor of history at Oberlin College in Ohio, has written a scholarly history of the Jet Propulsion Laboratory: *JPL and the American Space Program* (Yale University Press, 1982, xiii+299 pp., 20 illustrations). This work treats the Laboratory's history from its origins in Caltech in 1936 to the assumption of the Directorship by Lew Allen in 1982. A portion of chapter 6 appeared in somewhat different form in *JBIS* of August 1981.

Koppes' purpose is not only to detail the development of JPL but also to provide "a history of a national laboratory in relation to certain military and scientific policies in the national security state." In order to carry out this task, Koppes had free access to JPL's files, and indeed JPL internal memoranda are frequently listed among the 603 references.

One can distinguish five phases in Koppes' chronicle:

(1) the very early years: experimentation with rockets,

(2) the awakening of military interest in 1938 and into World War II,

(3) JPL as a weapons laboratory building missiles for tactical use by the US Army,

(4) becoming part of the NASA team in 1958 and the trials of forging a relationship with that agency while learning the craft of building interplanetary and lunar vehicles,

(5) mastery of the Solar System with the great planetary voyages of the 1970's.

Frank Malina was a graduate student in aeronautics at Caltech when he heard a lecture by William Bollay on rocketmotor experimentation by Eugen Sänger in Vienna. Malina's interest led him to propose to the eminent aerodynamicist Theodore von Kármán that he should write his dissertation on the subject of rockets. Von Kármán was director of GALCIT (Guggenheim Aeronautical Laboratory, California Institute of Technology). Follow-on experiments by Malina and a few colleagues in the nearby Arroyo Seco at the base of the San Gabriel mountains eventually led to what is now JPL.

By 1938 the GALCIT rocket project was drawing to a close when General "Hap" Arnold of the US Army Air Corps visited Caltech and became intrigued with possible military applications of rockets. A collaboration was established which led to the project's first major product: JATO (Jet-Assisted Takeoff) devices for aircraft. Koppes claims that as a result of the work in these early years, "the GALCIT project was the seedbed of American rocketry," and in particular he singles out the work on solid-propellant rockets. The author discounts the influence (but not quality) of Robert Goddard's work because of that researcher's secrecy, and he says that the GALCIT investigators were unaware of, and hence uninfluenced by, the German rocket work.

JPL officially came into existence in 1944 from the GALCIT project, and the Laboratory emerged from the war as a significant resource for the US Army. Frank Malina, who directed JPL until 1946, was replaced by Louis Dunn from the Caltech faculty, and the Laboratory began a period of devising missile systems for the Army. Conducted with a sense of national emergency during the so-called Cold War, the work resulted in the liquid-fuelled Corporal missile and the solid-fuelled Sergeant missile. Scaled-down versions of the latter vehicle were later used as upper stages in the launcher for Explorer I, the first US satellite. JPL not only engineered these advanced missile systems but also took part in the generation of training procedures for troop use. Not for the first time Caltech questioned JPL's role in weapons production as contrasted to its presumed research-role in rocketry.

In 1954 William Pickering, also from the Caltech faculty, replaced Dunn as Laboratory director, oversaw the quick development of Explorer I (see "Space at JPL" in February's *Spaceflight*), and moved JPL from its Army relationship to its connection with NASA. During the early 1960's, JPL also struggled to develop a credible lunar programme as both its Ranger and Surveyor projects suffered numerous early problems before successes. The successful early Mariners to Venus and Mars eased some of the pressure.

Koppes' primary interest in the JPL story ends as the 1960's draw to a close with JPL firmly established as "the world's premier space installation." He goes on to describe the Viking and Voyager triumphs and the reintroduction of military work during the Reagan administration.

Koppes' work is the most complete coverage of Laboratory history, but a recent, broad-based book by Homer E. Newell, a former Associate Administrator of NASA, presents an extensive discussion of the NASA/JPL relationship during the stressful 1960's. Newell, who retired from NASA in 1973, was an active participant in the important activities of these times and writes about "Jet Propulsion Laboratory: Outsider or Insider?" in Chapter 15 of *Beyond the Atmosphere: Early Years of Space Science* (NASA SP-4211, Washington, D.C., 1980, xviii+497 pp., 68 illustrations).

EQUATIONS ON THE COMPUTER

The dynamical complexity shown by Saturn's rings is matched by few other systems. However, Dr. Charles Tang of JPL has found a contender in his analysis of tethered space structures.

Tethered structures have been studied for more than a decade, but they have not yet been used in space (although some of the Gemini missions did perform some experiments). The use of a tether to connect two orbiting instruments can supply a long baseline for interferometric observation of astronomical radio sources or for stereo mapping of the Earth by synthetic aperture radars. A tether can also be of service in separating a payload from the Shuttle or a Space Station either to provide a cleaner environment for the payload or merely to create more storage space by using the skyscraper principle. The system is stable when the tether lies along a radius out from the centre of the Earth.

It is important to understand the dynamical properties of a tethered system so that a realistic spacecraft and mission design can be developed for each application. Because of the complexity, previous analyses were restricted to simplified models. The three-dimensional analysis, with various disturbing forces, which Tang is working on, is much more complex. Tang describes the task of even setting up these nine, coupled equations as "virtually insurmountable" by conventional methods since each would require a few thousand lines to write down. He has overcome the problem by using a computer-algebra program recently developed in the Physics Department at Caltech. The program, named "SMP" for Symbolic Manipulation Program, was written under the direction of Professor Barry Barish for applications in theoretical physics.

The use of computer programs to solve mathematical problems other than numerical computations is growing. There is a famous problem in mathematics, the four-colour map problem, that dates back over 100 years and until recently was unsolved. The solution was obtained using a computer program in a distinctly non-numerical fashion. Perhaps the best-known example of a non-numerical application is in chess; the best programs are now pressing the capabilities of the better (human) chess players.

By means of SMP, Tang will be able to finish the job in a relatively short time and without mental anguish. Also, if done by hand, it would inevitably contain numerous errors because of the sheer size of the undertaking.

BEYOND PLUTO

By David H. Hinson

Introduction

Even the most enthusiastic proponents of space travel have believed that exploration and exploitation of space would hit a snag at the orbit of Pluto. The gulf between our planetary system and the nearer stars is a million times greater than the distances separating the planets of our Solar System. Spacecraft capable of reach "our" planets in a year would need many thousands of years to reach the nearest known stars.

Starships would thus require a quantum leap forward in propulsion technology. There is little economic incentive apparent in developing such engines: they would be grossly overpowered for trips to the planets, while the stars are still decades away. Starships would not be the inevitable result of colonization and economic expansion but would rather need a kind of "super-Apollo" programme. We cannot be sure that any space-faring civilization would do such a thing.

Nearer to Home

If there were interesting and/or economically important bodies at intermediate distances from the Sun this picture could change drastically. No quantum leap forward would be needed, gradual improvements in technology would suffice. Expansion past Pluto would be much more likely, perhaps inevitable.

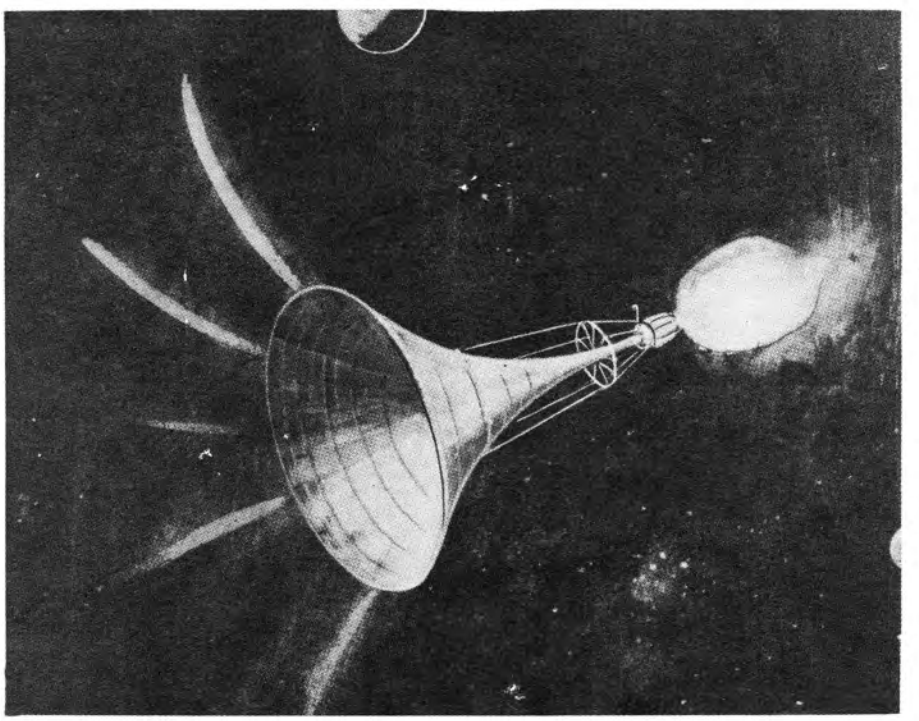
Fortunately, this seems to be the case. For one thing, long-period comets have very eccentric orbits, travelling as far as 100,000 AU from the Sun (one AU is equal to 150 million km, the distance between the Earth and the Sun). This is equal to 1.6 light-years, or more than a third of the way to Alpha Centauri.

At first glance we might think that comets wander freely through interstellar space until captured by a passing star. But this cannot be the case. A comet falling around the Sun from intersellar space would have an open-ended, hyperbolic orbit. Very few comets have been observed with such orbits, and even those that have are near the borderline between open and closed orbits. They could well have originally had very elongated (elliptical) orbits, since only a very small perturbation would be needed to change such an orbit to a hyperbola.

In 1950, Oort noticed that long-period comets tend to have elliptical orbits with aphelia (points farthest from the Sun) of 30,000 to 100,000 AU. He decided that there is a vast reservoir of comets in this region, a huge cloud surrounding the Sun. They would initially be in roughly circular orbits, but perturbations due to the nearer stars would send them falling toward the Sun. The aphelion of the resulting elliptical orbit would be roughly equal to the comet's original distance from the Sun. In passing, we should note that 30,000 AU may not represent an inner boundary to the Oort cloud. Comets in near-circular orbits between 100 and 30,000 AU could be too close to the Sun for the nearer stars to perturb, and too far out for the planets to influence. Thus, they would stay in this region, never approaching close enough to be observed.

A comet in the Oort cloud will have little resemblance to those we see in the inner Solar System. There, the large coma and tail are made up of dust and gas excited by solar radiation. In its normal state, a comet is a ball of frozen gases possibly with a small rock and metal core. It is at most a few tens of kilometres in diameter.

Comets should contain abundant water, carbon and oxygen, the basic requirements of life, and could support a small community. With many thousands of millions of comets in the Oort cloud the outermost Solar System becomes a vast new frontier. The great distances and potentially immense number of settlements would likely be thought of as ungovernable as a whole. It might become a refuge from centralised governments.

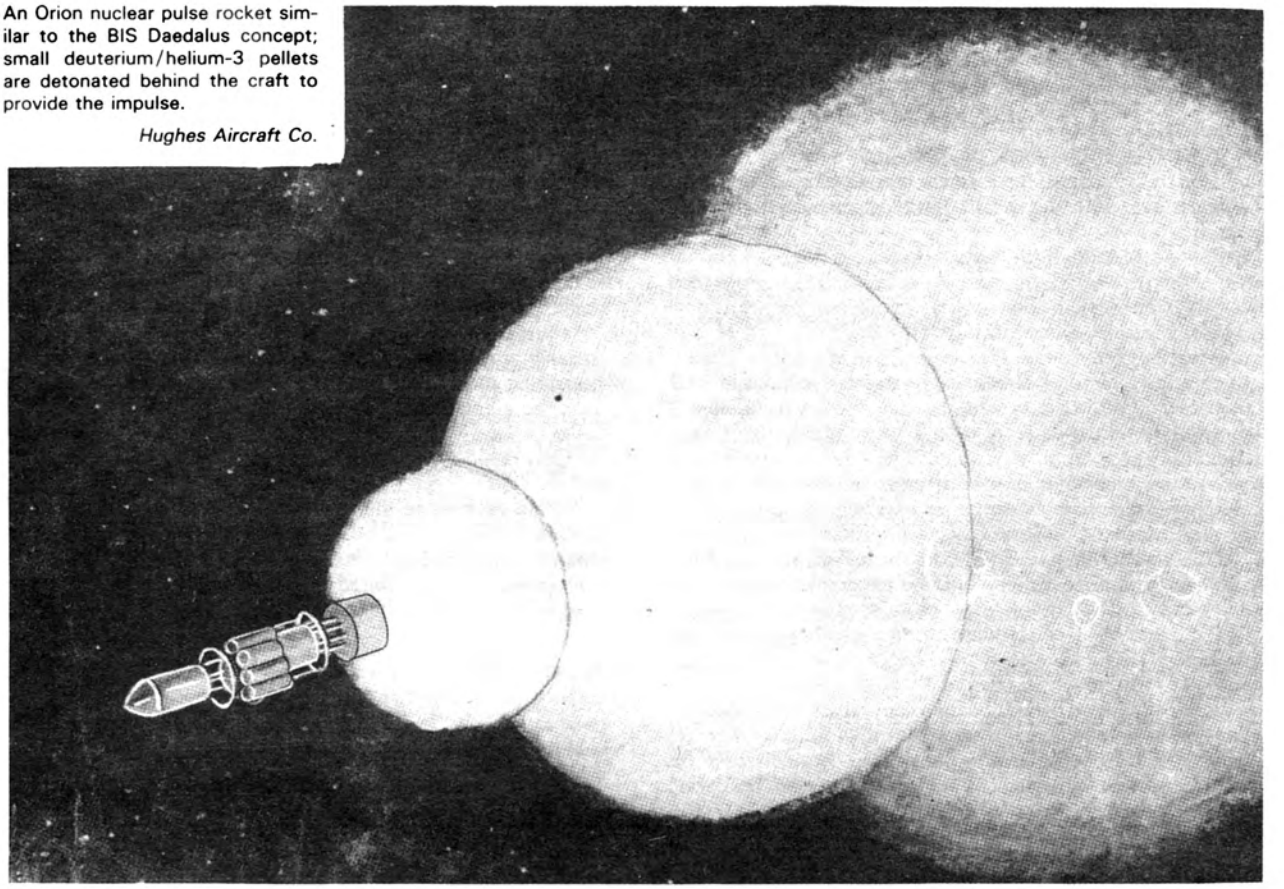


A Bussard interstellar ramjet collecting the tenuous hydrogen gas spread out between the stars for propellant.

Hughes Aircraft Co.

An Orion nuclear pulse rocket similar to the BIS Daedalus concept; small deuterium/helium-3 pellets are detonated behind the craft to provide the impulse.

Hughes Aircraft Co.



Robert L. Forward has proposed interstellar craft with large sails propelled by powerful lasers based at the starting point.

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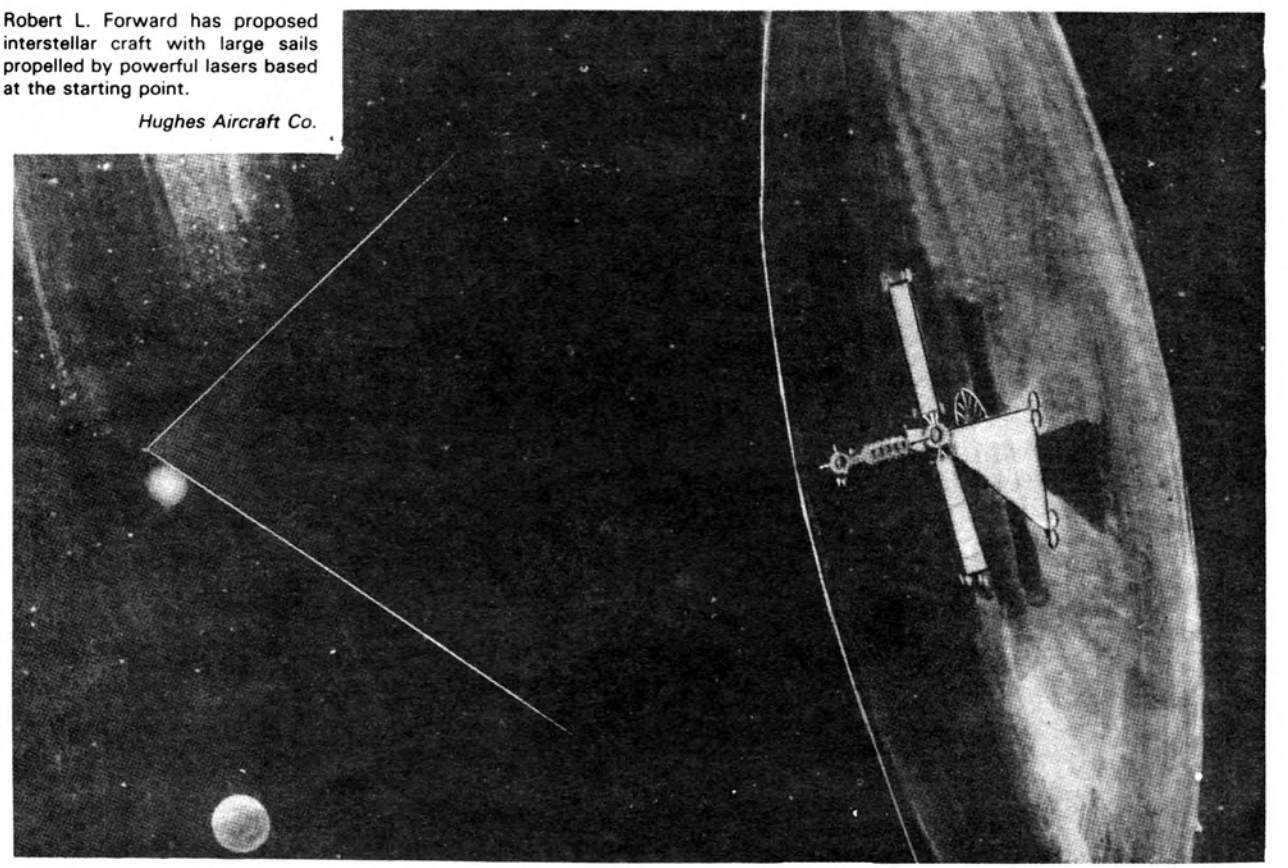

Comet Colonisation

The nature of this colonisation will depend on how well people can adapt to very low gravity (practically free fall). No man has spent more than six months in continuous weightlessness, so we still do not know if we can live in zero-gravity indefinitely.

If gravity is a long-term physiological need, it must be simulated by centrifugal force. Some kind of artificial structure will be needed, with the comets used only as a source of raw materials.

On the other hand, if the human body does not need gravity (or can be so altered by genetic engineering) comets can themselves be settled. The settlers could use "conventional technology", with domed or underground settlements and fusion reactors for energy. However, there is a possible alternative to this picture. Freeman Dyson has proposed that comets could be settled by what he calls "green technology". Genetically engineered trees would grow hundreds of kilometres into space from the comet. Their leaves would have two parts: an inner photosynthetic part would be surrounded by focusing mirrors or lenses. The bark would need to be a very good insulator, and the oxygen produced would be sent to the roots rather than released from the leaves, as in a natural tree. Some kind of covering would be needed to keep the air in.

This second style of colonisation has advantages and disadvantages. It would probably be cheaper once the trees were developed. Also, much less payload would need to be sent to the Oort cloud. But it might take many years to establish a habitable environment in this manner. Furthermore, since the colonies would be dependent on the Sun, at some distance we would expect "conventional technology" to be more desirable. In fact, "green technology" may be more appropriate to the smaller moons of the outer planets than to the comets. But perhaps both styles of colonisation will occur in the Oort cloud, according to the preference of the settlers.

Getting There

Many authors have proposed spacecraft that are marginal for true interstellar missions but adequate for trips to the Oort cloud. For example, Matloff has proposed an "interstellar ark" based on a Type I O'Neill colony. The basic colony consists of two adjacent cylinders, 100 m in diameter and 1000 m long. Each cylinder could house 5000 people. Rotation of the cylinders about their axes simulates gravity. Matloff suggests that the colony could be propelled by a nuclear fusion pulse rocket similar to that proposed for the BIS Daedalus study. This rocket uses the explosive thermonuclear fusion of 10 cm diameter pellets of deuterium and helium-3. With 150,000 tonnes of fuel, a colony could reach 0.01 the speed of light. An electrostatic drag sail would use the interstellar medium for braking. On-board power would be provided by a fusion reactor.

Since helium-3 is very rare, a fusion rocket using only deuterium would be better from the supply point of view. If this can be built, the colony could refuel from a comet's frozen gases. Each comet would contain enough deuterium for thousands of trips. These colonies could engage in trade between themselves, cometary settlements and the inner Solar System. Artifacts could be one item of trade, along with trace elements needed by the human body. Information would be one of the most important trade items. For example, scientific establishments might pay a great deal for first-hand reports from regions far from the Sun, saving them the expense of sending out their own expeditions.

Another type of body may be abundant in the solar neighbourhood. Kumar has suggested that very small stars, or infrared dwarfs, are abundant in the region. These would have masses between 0.01 and 0.07 times that of the Sun, too small for hydrogen fusion to occur, but still hot from energy released by their gravitational collapse. Their surface temperatures could be as high as 2000 K, but their luminosities would be less than one thousandth that of the Sun.

If Kumar is right, from five to 50 infrared dwarfs could exist within a light-year of the Sun. Indeed, we could be part of a multiple star system. These stars could be reached by mobile O'Neill colonies. They might go in search of marketable information, or they could find planets or other bodies orbiting a dwarf. However, with such low luminosities, habitable planets seem unlikely. If any were close enough to be warm they would probably be tidally locked with their primaries, with one side in permanent light and the other in eternal darkness. This would make a habitable world even less probable.

As suggested earlier, there would be economic incentives to improve propulsion technology. Rockets capable of using the interstellar medium as fuel or reaction mass are a possibility. Also, the giant lasers that Forward proposed to propel interstellar probes with light sails could be used to send ships to the Oort cloud as well, giving an economic incentive for their construction.

The region around the Sun could support a vast number of different societies. The overall picture strongly resembles the vision of James Blish in his *Cities in Flight* series, with mobile cities trading with inhabited planets. The two pictures become even more alike once the planets of the nearer stars are settled.

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Editor's note: Helium-3 was chosen for the BIS Daedalus study after careful thought. The Daedalus reaction would produce protons as motor reaction particles and would not be a radiation hazard. The deuterium suggested above would produce ~14 MeV of neutron radiation and would require considerable shielding. Indeed, the search for the infrared "stars" could be motivated by the search for helium-3.

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THE SOVIET SPACE SHUTTLE

By Gerald Borrowman

Introduction

The 1980's will be remembered as the era of the manned reusable winged spacecraft. As the first orbital test flight of the Shuttle Orbiter *Columbia* approached, the Soviets undertook a vigorous campaign against the craft as a military vehicle. The official Soviet news agency published charges that the Shuttle was part of the arms race into space. A comment from Moscow on 13 April 1981 said:

"People in the Pentagon are gleefully rubbing their hands. After all, more than two-thirds of the Shuttle flights are to be made in the Pentagon's interests. The ship's 30-ton carrying capacity will enable it to put around the Earth orbit spy satellites of a new generation, military laser stations and other military hardware. The Pentagon regards the Shuttle as a spacecraft intended for shooting down the enemy's artificial satellites or seizing and bringing them to the vehicle in the role of an omnipotent and (insatiable) space pirate. . ."[1].

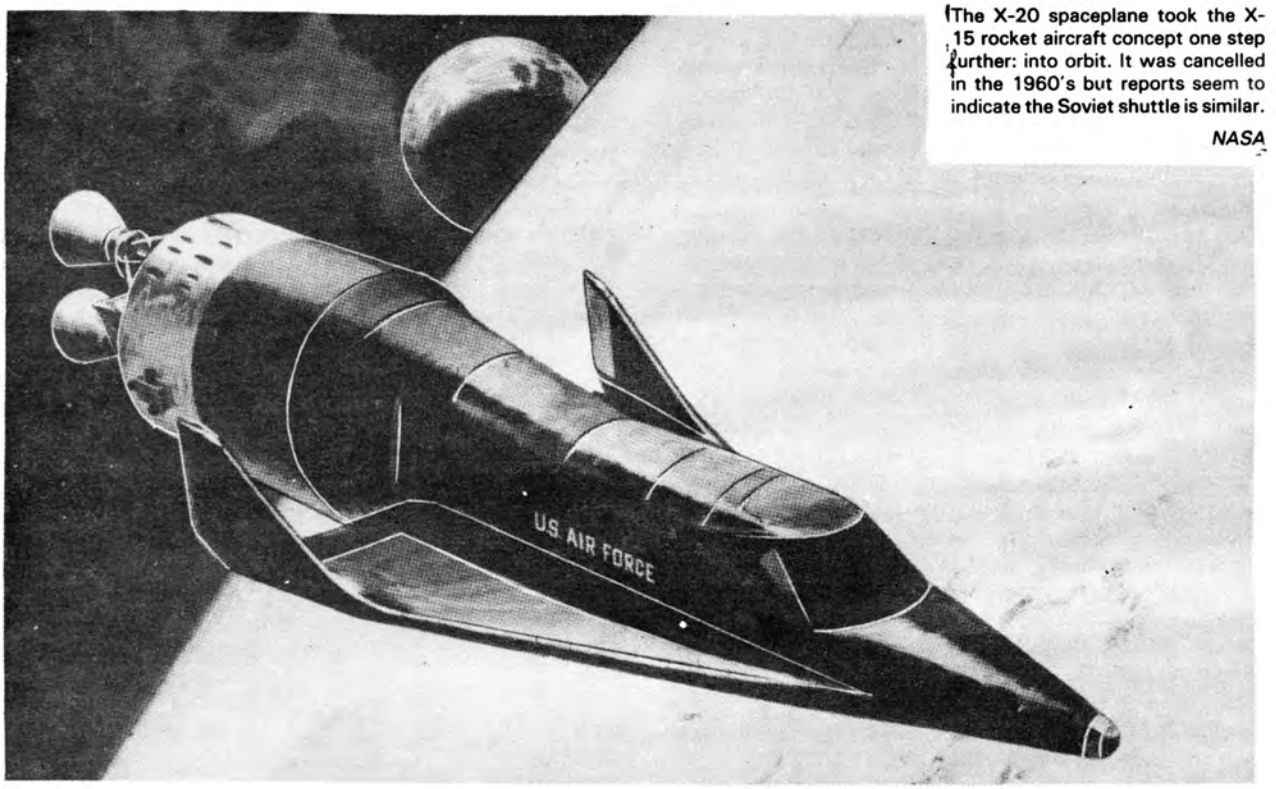
Typical of the attacks was a Soviet spokesman delivering a paper before the XIV Colloquim on International Law of Outer Space in which it was implied that *Columbia's* Remote Manipulator System would be used to retrieve space objects as a prelude to acts of orbital piracy. The attack included a denial by cosmonaut Alexei Yeliseyev at the Rome IAF Congress in September 1981 that the Soviets were planning a similar type of spacecraft [2].

Significantly, this debate occurred as the space age entered the third decade of manned space flight, with the Soviets having logged some 1,900 man-hours in space.

TABLE 1. Early Kosmoljot Development.

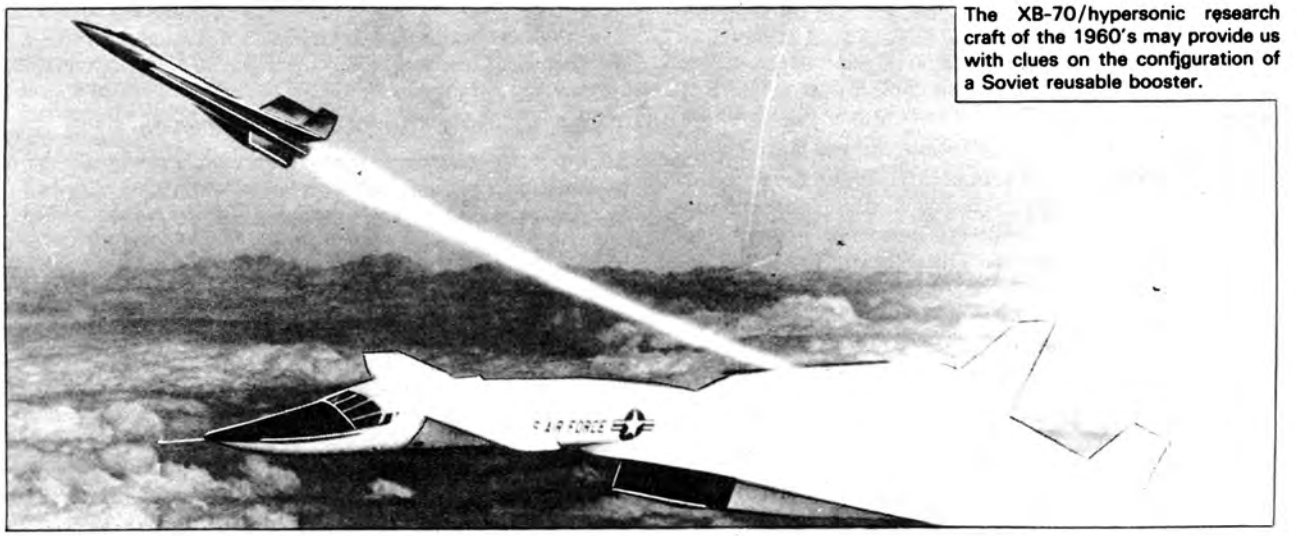
Early Kosmoljot Development (probably conducted by Artem Mikoyan).	1962
Reports of Kosmoljot drop-tests.	1970's
Dual craft Proton missions.	1976–1979
Soviet planners elaborate on Kosmljot "Aeroflot-type" operations.	mid-1979
Debates rages as to the utility of winged spacecraft.	1981
Cosmos 1374 flight atop a C-1 booster.	1982
Possible flight tests atop Proton booster.	Future
Kosmoljot flies atop fly-back booster.	Future

In spite of the denials, the Soviet Union completed the first orbital test flight of the orbiter element of the "Kosmoljot" in June last year. This confirmed the statement by Anatoli Y. Skripko, the Soviet science and technology attaché in Washington, that the Soviet Union was developing a system "to considerably reduce the cost of delivery of materials into orbit." This craft is to serve as an integral part of advanced space station operations [3].



The X-20 spaceplane took the X-15 rocket aircraft concept one step further: into orbit. It was cancelled in the 1960's but reports seem to indicate the Soviet shuttle is similar.

NASA



The XB-70/hypersonic research craft of the 1960's may provide us with clues on the confjguration of a Soviet reusable booster.

Cosmos 1374

Soviet space programme officials have indicated that they presently see no need for a shuttle type of craft, and that the Soyuz and Progress vehicles are adequate.

Yuri Zaitsev, department chief of the Space Exploration Institute of the USSR Academy of Sciences, has said that the transporation "supply system for durable orbital stations, based on the relatively cheap manned spaceships Soyuz and automatic supply vehicles Progress, should be considered today most efficient and advisable" [4].

These are highly significant comments since the Salyut 6 mission consumed 33 individual Soyuz and Progress spacecraft/booster configurations, in addition to the Cosmos 1267 "Star" module.

The unmanned Kosmoljot flight test, Cosmos 1374, was launched at about 9.30 p.m. GMT on 3 June 1982, and was recovered about 350 ml (560 km) south of the Cocos Islands after a flight of about 109 minutes. The 2,000 lb (900 kg) sub-scale model of the "Albatross" was placed in orbit by a C-1 booster from Kapustin Yar [5].

Cosmos 1374 was the fourth flight to be directly associated with the development of the Kosmoljot (see Table 1). The Albatross test had been anticipated by several observers of the Soviet space programme [6].

On 17 March 1981 Robert S. Cooper, director of DARPA (Defense Advanced Research Projects Agency), informed the Senate Subcommittee on Strategic and Theater Nuclear Forces that Soviet space developments "certainly portend the advent of a new modular space station for the Soviets and move them along the way toward the goal of a large permanently manned space station." He added that the Soviets were "working on a manned space plane related to the current Salyut space station programme" [7].

The deputy commander of the Soviet manned space flight training programme, Maj.-Gen. Alexei A. Leonov referred to Cosmos 1374 as an "experimental spacecraft." "The Soviet Union on Friday (3 June 1982) indeed launched an experimental spacecraft – the next one in the Cosmos series" [8].

The testing of the Albatross bears a marked similarity to the aerothermodynamic/aerothermoelastic structural systems environmental test (ASSET) gliders flown atop Thor boosters in the early 1960's. The ASSET gliders with their 70° swept stub 14 ft (4.3 m) stub wings were nearly identical to the Dyna-Soar shuttle concept. The ASSET gliders were used to collect data on high-speed flutter phenomenon and aerodynamic control characteristics. They were half-conical in shape and approximately 78 in (2 m) long with a 54 in (1.4 m) span [9].

TABLE 2. Kosmoljot-Related Flight Tests.

Cosmos 881/882 Cosmos 997/998 Cosmos 1100/1101	possible fly back booster tests.
Cosmos 1374	Albatross sub-scale model flown.

Testing of the thermal protection of Albatross was certainly one of the prime objectives of Cosmos 1374.

Recovery of the Cosmos 1374 sub-scale craft would have been a high-priority, as evidenced by the presence of seven ships in the recovery area. Perhaps flotation bags were carried [10].

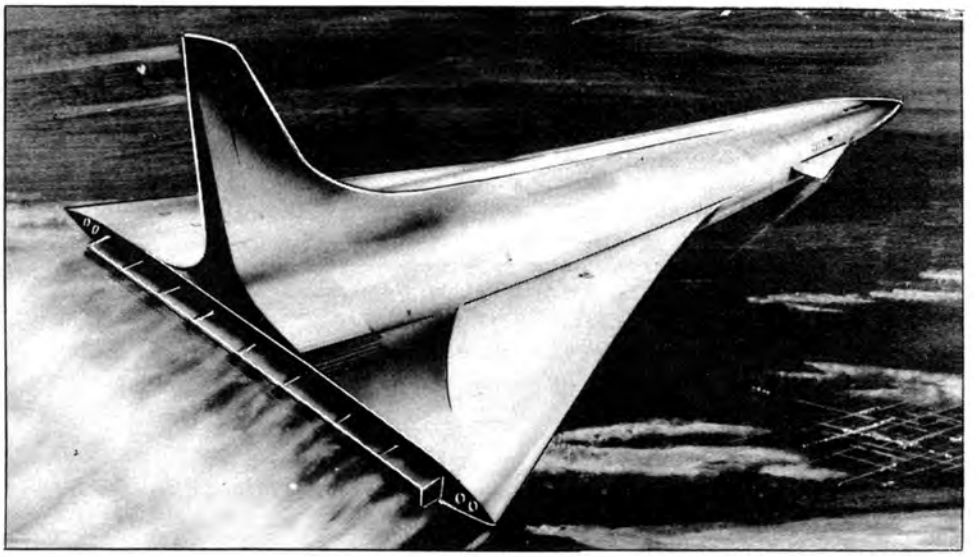
According to some sources, the Royal Australian Navy obtained "a few pictures" as "the craft dropped by parachute to the recovery site. . ." [11].

Recovery would have permitted engineers to study the effects of re-entry heating and to determine structural behaviour of the vehicle. They would have been looking at temperatures, pressures, heat transfer rates, lift, drag, and material behaviour.

According to Skripko, a goal of Kosmoljot to reduce payload-to-orbit costs to one-tenth that of the US Shuttle; that is, 20-25 roubles per kg (about $0-37.50) [12].

The dual Proton missions of Cosmos 997 & 998, 881 & 882, and 1100 & 1101 were part of the development of the flyback Kosmoljot booster. The first two Cosmos missions were returned to Earth after

A US concept for an advanced shuttle craft.



less than one orbit. Cosmos 1100 and 1101 had one craft returned on the first revolution, the second craft on the second revolution.

Estimates on the size of these bodies vary, from about 9,000 kg (19,800 lb) to more than double the weight of Soyuz, or 6,800 kg (14,960 lb).

Kosmljot Future Development

Skripko said that the development of Kosmoljot "is a very complicated problem, the solution of which will require much time, effort and funds. But this task will be worked on. Only this system can make the existence of giant complexes in orbit and the mastering of outer space for the needs of mankind possible.

"Scientists will have to create not only powerful rockets and special technology capable of delivering cargoes to orbit at a low cost, but, what is equally important, orbital factories specializing in the production of certain units and construction elements of giant stations and special devices for their assembly. Man is likely to take part in this work" [13].

Kosmoljot's payload potential may depend to a large extent upon the development of high-energy oxygen/hydrogen engines. These engines may also be part of the second and third stages of the new Soviet heavy booster. Such a development project would represent a significant commitment of resources, comparable to that of developing the Saturn V in the United States.

It is reasonable to assume that the flight systems aboard Albatross will be sufficiently automated through the use of computers to permit a two-man crew to fly the craft. This would allow the maximum number of passengers. Thus Albatross would carry the members of the crew to the yet-to-be-orbited heavy space station, which may have facilities to support 20 inhabitants in the short term and 100 cosmonauts if the Soviets expand orbital operations in the long term. The latter scenario could involve more than one heavy station in orbit simultaneously. This could entail the launch of the new heavy booster, with a payload capability of approximately 220,000 kg (485,000 lb) as many as four times a year.

The reusable Kosmoljot will reduce the amount of expendable hardware required to conduct space station operations. Thus, Albatross flights atop an expendable launch vehicle, such as the Proton, should have been phased out by the time the reusable craft is required to man a series of large stations. This stage of Kosmoljot development could be typified as approximating "Aeroflot"-type airline operations.

Thus Kosmoljot will play a vital role in the "setting up of industrial enterprises in some distant future, which will turn out certain materials which are very difficult or simply impossible to produce on Earth. . ." [14].

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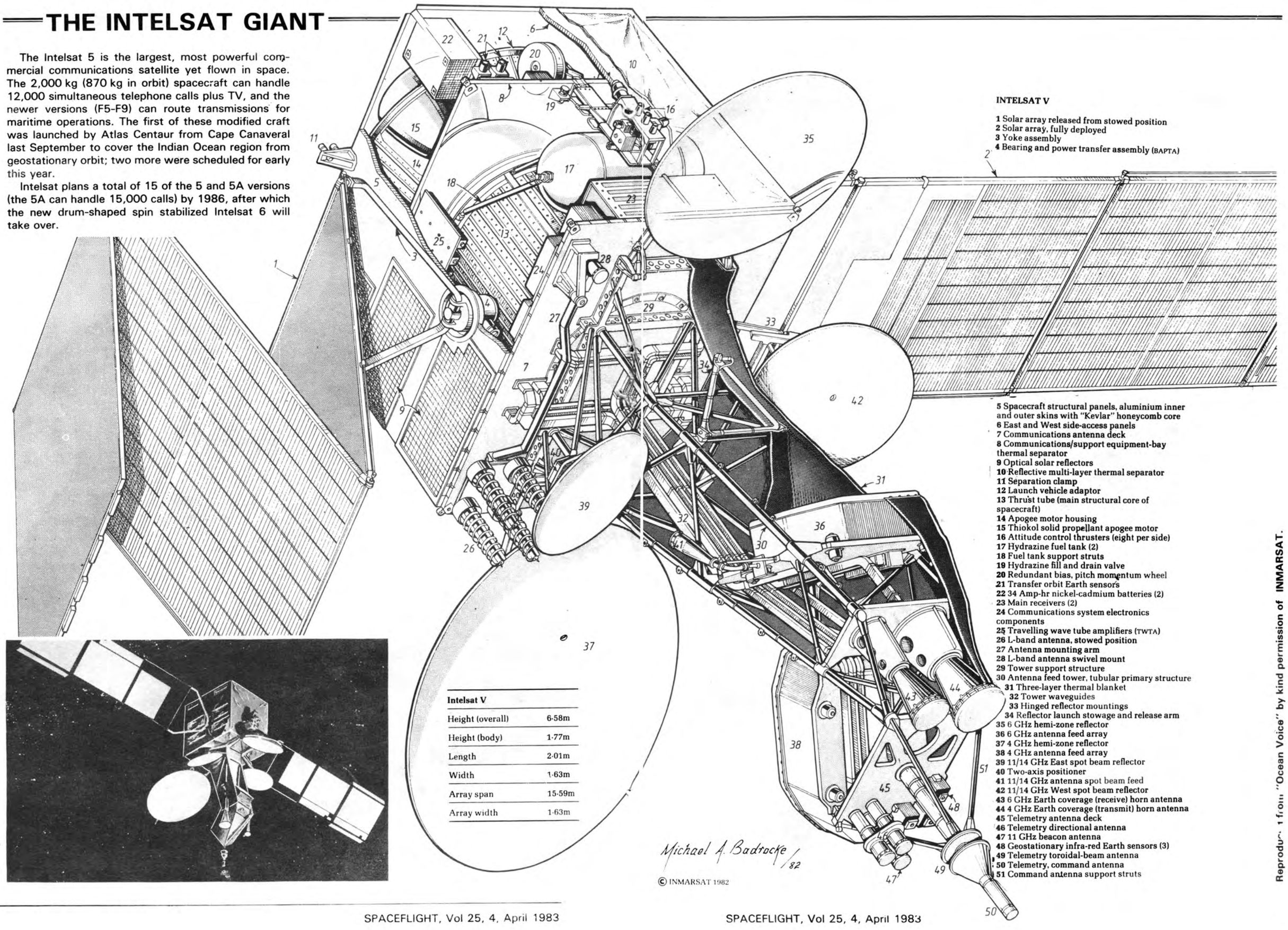
THE INTELSAT GIANT

The Intelsat 5 is the largest, most powerful commercial communications satellite yet flown in space. The 2,000 kg (870 kg in orbit) spacecraft can handle 12,000 simultaneous telephone calls plus TV, and the newer versions (F5-F9) can route transmissions for maritime operations. The first of these modified craft was launched by Atlas Centaur from Cape Canaveral last September to cover the Indian Ocean region from geostationary orbit; two more were scheduled for early this year.

Intelsat plans a total of 15 of the 5 and 5A versions (the 5A can handle 15,000 calls) by 1986, after which the new drum-shaped spin stabilized Intelsat 6 will take over.



Intelsat V	
Height (overall)	6·58m
Height (body)	1·77m
Length	2·01m
Width	1·63m
Array span	15·59m
Array width	1·63m

INTELSAT V

1 Solar array released from stowed position
2 Solar array, fully deployed
3 Yoke assembly
4 Bearing and power transfer assembly (BAPTA)
5 Spacecraft structural panels, aluminium inner and outer skins with "Kevlar" honeycomb core
6 East and West side-access panels
7 Communications antenna deck
8 Communications/support equipment-bay thermal separator
9 Optical solar reflectors
10 Reflective multi-layer thermal separator
11 Separation clamp
12 Launch vehicle adaptor
13 Thrust tube (main structural core of spacecraft)
14 Apogee motor housing
15 Thiokol solid propellant apogee motor
16 Attitude control thrusters (eight per side)
17 Hydrazine fuel tank (2)
18 Fuel tank support struts
19 Hydrazine fill and drain valve
20 Redundant bias, pitch momentum wheel
21 Transfer orbit Earth sensors
22 34 Amp-hr nickel-cadmium batteries (2)
23 Main receivers (2)
24 Communications system electronics components
25 Travelling wave tube amplifiers (TWTA)
26 L-band antenna, stowed position
27 Antenna mounting arm
28 L-band antenna swivel mount
29 Tower support structure
30 Antenna feed tower, tubular primary structure
31 Three-layer thermal blanket
32 Tower waveguides
33 Hinged reflector mountings
34 Reflector launch stowage and release arm
35 6 GHz hemi-zone reflector
36 6 GHz antenna feed array
37 4 GHz hemi-zone reflector
38 4 GHz antenna feed array
39 11/14 GHz East spot beam reflector
40 Two-axis positioner
41 11/14 GHz antenna spot beam feed
42 11/14 GHz West spot beam reflector
43 6 GHz Earth coverage (receive) horn antenna
44 4 GHz Earth coverage (transmit) horn antenna
45 Telemetry antenna deck
46 Telemetry directional antenna
47 11 GHz beacon antenna
48 Geostationary infra-red Earth sensors (3)
49 Telemetry toroidal-beam antenna
50 Telemetry, command antenna
51 Command antenna support struts

Michael A. Badrocke /82

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CELEBRATING GODDARD'S CENTENARY

By Frank H. Winter*

Goddard's Accomplishments Assessed

The achievements of the American rocket pioneer Robert H. Goddard were honoured world-wide on the centenary of his birth on 5 October 1982, which ironically almost exactly coincided with the 25th anniversary of the launch of Sputnik 1. Without the pioneering work of men like Goddard the Space Age would not have been possible at all. Perhaps his best-known accomplishment was launching the first liquid-propellant rocket at Auburn, Massachusetts, on 16 March 1926.

Goddard's impact upon rocketry is difficult to assess because of his well-known secrecy and reluctance to release any details of his work until positive results had been achieved. The historic 1926 flight was at first known only to his assistants and Smithsonian Institution offocials (his research was then supported by a Smithsonian grant). Goddard perhaps made his first public claim to the flight in the June–July 1931 issue of the *Bulletin of the American Interplanetary Society* in response to a statement in the May issue which mistakenly reported that up to that time no liquid-fuel rocket had ever flown! Some of the details of his liquid-fuel work subsequently appeared in his second Smithsonian report of 1936, *Liquid-Fuel Rocket Development*. In the meantime, several independent experimenters in Germany, the US and the USSR built and launched their own liquid rockets.

One thing is certain: the world awoke to the possibility of space flight by rocket after the publication of Goddard's first Smithsonian report, *A Method of Reaching Extreme Altitudes*, published late in 1919, in which he very briefly suggested liquid-propellant rocket propulsion. The bulk of the paper concerned his solid-fuel researches.

In almost all of the hundreds of newspaper and magazine articles appearing world-wide from 1920, Goddard's name is invariably mentioned. Strangely, the name of Konstantin Tsiolkovsky, the earlier great Russian space travel theorist, is usually absent. Tsiolkovsky began his own investigations into the possibility of space flight from the 1880's but his publications do not seem to have reached the West until the late 1920's. Neither were they translated from the Russian until years later.

From Goddard's posthumously-published papers as well as his unpublished papers, we now know of his brilliant technological accomplishments encompassing fundamental inventions and techniques in modern liquid-fuel rocketry. During his lifetime, Dr. Goddard was awarded 48 patents. Through the efforts of his widow, the late Esther Goddard, 131 additional patents were issued posthumously from his notes and afadavits for a total of 214 patents. Because of the real possibility of infringements on Goddard's ideas, the newly-created National Aeronautics and Space Administration (NASA) acquired the rights to use more than 200 of the patents in a settlement with Mrs. Goddard in August 1960 amounting to $1,000,000.

The world's first liquid-propellant rocket was launched by Goddard on 16 March 1926, from a farm near Auburn in Massachusetts. Note that the motor is in front of the propellant tanks, covered with an asbestos heat shield.

NASA

The Celebrations

Fittingly, the largest of the Goddard centenary celebrations was held at Worcester in Massachusetts, Goddard's home town where he was born on 5 October 1882. I was fortunate enough to be able to attend and also took the opportunity to continue researching into the still-largely untapped Goddard papers in the Rare Book Room of Clark University's Robert Hutchings Goddard Library. In addition to the celebrations, there was a display case honouring the late Mrs. Goddard who passed away in Worcester on 4 June, aged 81.

* Historian, Space Science and Exploration, National Air and Space Museum, Washington, D.C.

There is a very nicely arranged permanent Robert H. Goddard exhibit here which drew many of the centenary visitors.

The proceedings began on an exceptionally fine sunny morning on 5 October on Pakachoag Hill, facing Upland Street, Auburn, just outside of Worcester where, on a bitterly cold day in 1926, Goddard made his historic launch from the snow-covered ground. This time, on top of the hill (now part of the Pakachoag Golf Course), a full-scale replica of Goddard's 1926 plumbing pipe launch frame was set up in which was mounted a replica of the rocket.

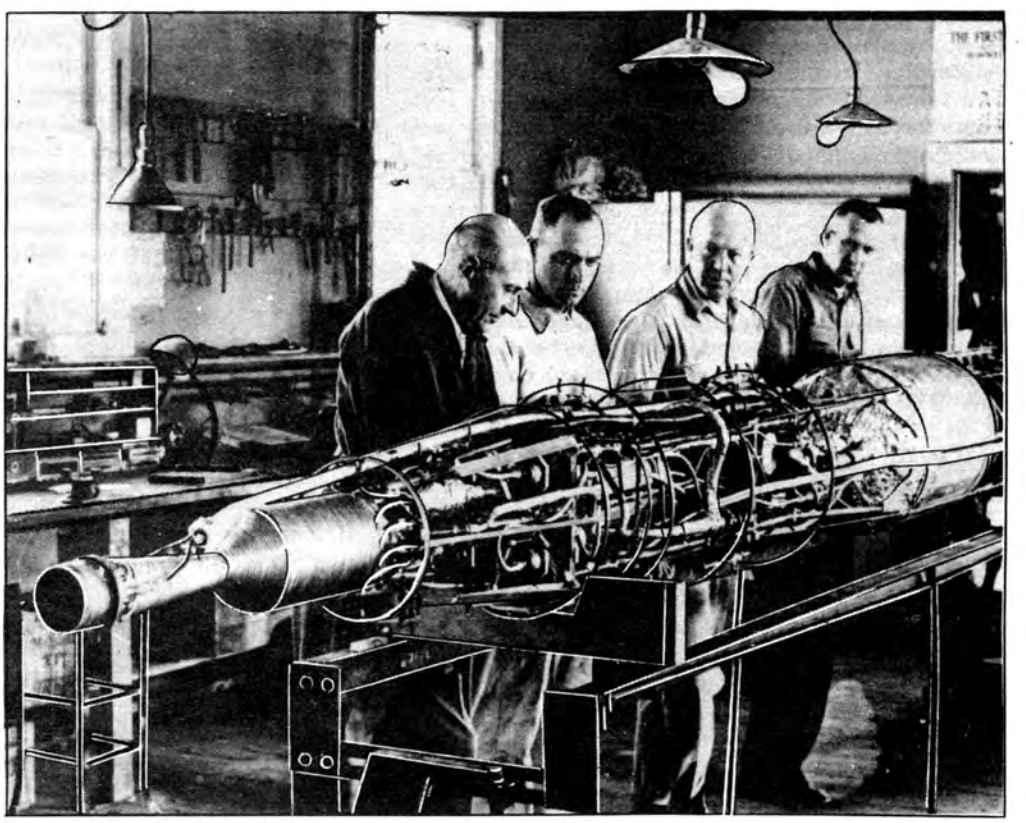
While positioning myself to get a good viewing spot, I overheard an elderly gentleman saying that he last saw Goddard in 1930 (i.e. when he left Massachusetts and went to Roswell, New Mexico, to continue his rocket experiments there). The man was octogenarian Wilfrid J. Charbonneau who, as a youngster, had delivered newspapers to Goddard and had often chatted with the pioneer on his front porch. The two had been neighbours. Later that night, the TV news interviewed another witness to the day's proceedings, Walter J. Beinar, who said he had actually seen Dr. Goddard's rocket flying on that historic day. How many others amongst the spectators had similarly touched history it is hard to say.

Below Pakachoag Hill, about 500 ft (150 m) away, was the actual launch site, marked with a modest stone monument dedicated by the American Rocket Society in 1960 (Mrs. Goddard, Wernher von Braun and other dignitaries had attended the ceremonies). Now, on this beautiful October morning in 1982, there were several members of the Shrewsbury Junior High School Rocket Club waiting to fire some model rockets.

At about 10 a.m. the dignitaries arrived on Upland Street in a colourful procession of vintage 1920's to 1930's cars. Amongst them were the Master of Ceremonies and General Chairman of Worcester's Robert H. Goddard Centennial Celebration and Exposition, Neal Finnegan. NASA was represented by the future Spacelab (STS-9) pilot, astronaut Brewster Shaw. Dr. Mortimer Appley, President of Clark University, where Goddard obtained his PhD in 1911 and conducted some of his early experiments, also spoke. Also present was Dr. Edmund Cranch, President of Worcester Polytechnic Institute, where Goddard obtained his BS in 1908 and where he also likewise experimented. Archivist Terry Bragg who, under a grant from the Daniel and Florence Guggenheim Foundation, completed a register of all the Goddard papers earlier in 1982, gave the benefit of his own intimate knowledge of Goddard and his accomplishments. In the audience was Mrs. Beatrice Kisk, Goddard's sister-in-law.

Then Felix Tozeski, dressed up as Robert Goddard in his laboratory coat and high peaked cap, emerged from one of the antique cars on the road. With him was an assistant similarly dressed. The pretend Goddard, with simulated blow torch on a pole, went over to the replica and "touched it off". Instantly, a long flame shot out of the nozzle. The blow torch was in reality a propane burner while inside the rocket nozzle was a small gas bottle. Meanwhile, the boys of the Shrewsbury Rocket Club were firing 11 real rockets (the 1926 replica was not designed to fly) which were gently recovered with small orange parachutes.

Following the "lift-offs", the dignitaries paraded their



As World War II appeared on the horizon, Goddard's rockets were becoming larger and more sophisticated. The workshop and assembly plant at the Mescalero Ranch at Roswell in New Mexico became crowded, as shown here in 1940.

antique cars back to Worcester to the next event, the opening of the Robert H. Goddard Centennial Exposition in the brand new Centrum convention hall. They were joined by Congressman Joseph Early, a strong pro-space advocate who announced the passing of House Joint Resolution 568 designating 5 October as Dr. Robert H. Goddard Day. President Reagan later signed a Presidential Proclamation to this effect in which US flags were ordered to be displayed on all Government buildings.

The Exposition, which was to attract an estimated 75,000 people in three days, featured industrial and space displays.

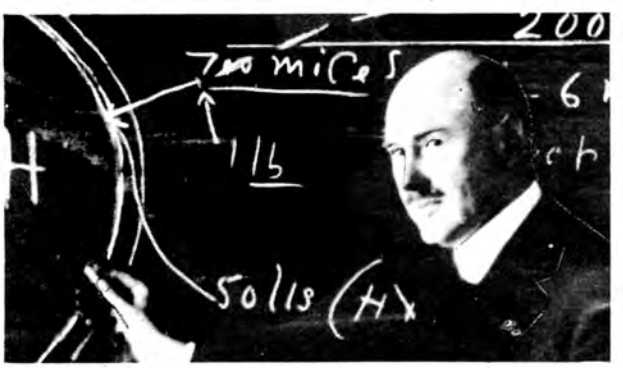
Adorning the hall was a giant cake, decorated as the Pakachoag Hill launch site and complete with a model of the 1926 rocket. It was all devoured by many of the visiting students on the final day of the Exposition!

On the final day of the celebrations, 7 October, Worcester's Industrial Park Road was renamed as the Robert H. Goddard Memorial Drive. In another ceremony, a plaque was placed on the house where Goddard was born at One Tallawanda Drive, the house was proclaimed to be a Worcester historic site.

Though not part of the Centenary programme, science fiction author Issac Asimov was delivering a lecture that week at Worcester Polytech on "Our Future in Space". His opening remarks also noted the anniversary. "This is a time of dates", he said. "4 October marked the 25th anniversary of space flight. The following day commemorated the 100th anniversary of Robert H. Goddard's birth. When the Russians launched Sputnik they were probably trying for the 100th birthday of their Konstantin Tsiolkovsky (born 5 September 1857) but in any case they almost made the 75th anniversary of Goddard!"

Celebrations Elsewhere

At NASA's Goddard Space Flight Center Dr. Tom Crouch of the National Air and Space Museum presented a slide lecture of the life and works of Goddard in a special colloquium in which alumni of Clark University and Worcester Polytech attended. A reception and tour of the facilities which includes some Goddard artifacts at the Visitor's Centre was held afterwards. The Center's *Goddard News* also came out with a special Robert H. Goddard issue. In Baltimore, Maryland, where Goddard died in 1945, the Baltimore Science Center presented a programme which included films of Goddard's works.



Parachute recovery of rockets was necessary for a very practical reason: hand-made components were expensive, radio telemetry non-existent, and materials were scarce. The problem of a reliable parachute recovery system gave Goddard much trouble. This recovery in 1937 was relatively successful.

NASA

In the mid-part of the country the Michigan Space Center at Jackson, Michigan, received a good response with its own presentation of a Goddard film, a NASA-produced film entitled "The Empty Frame", referring to Goddard's launch frame. This museum also has a Goddard exhibit with artifacts. Press stories also appeared.

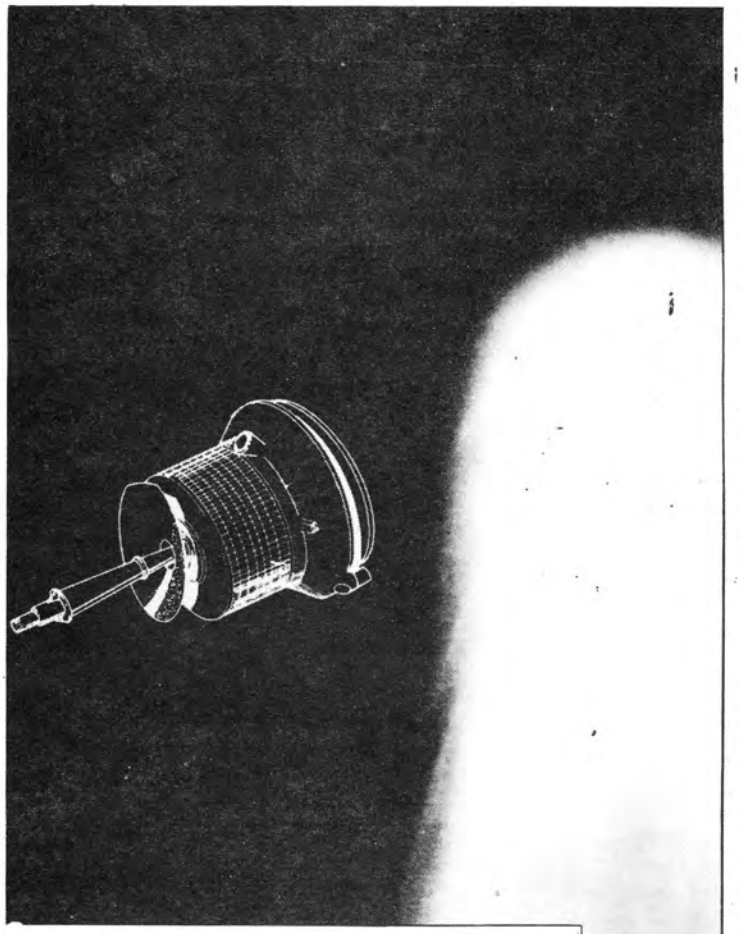
Out West, newsmen interviewed 85-year-old Dr. Percy Roope in Cambria, California. He is the last living official witness and assistant for that first flight. It was Roope who recorded the time and altitude of the rocket on his stopwatch and theodolite. Roope had met Goddard as a physics student at Clark University and later he succeeded Goddard as Chairman of Clark's Physics Department until retirement in 1962.

In the USSR, according to Frederick Durant, former Assistant Director, Astronautics, of the National Air and Space Museum, the Soviets held a celebration commemorating the 25th anniversary of the launch of Sputnik 1. Durant, who was present, noted that traditional hearty Russian toasts were also offered to the memory of the American Dr. Goddard and his birthday. The Russian translations of Goddard's writings and a Russian language biography have also been noted.

However the centenary was celebrated, it is certain that the memory of Robert H. Goddard is cherished.

The December 1982 "Astronautics History" issue of JBIS *contains a detailed description of Goddard and his work by space historian Mitchell Sharpe. Individual copies are available at £2 ($5)*—Ed.

RENDEZVOUS WITH HALLEY'S COMET



The Story So Far . . .

On the night of 16 October 1982, Halley's Comet was detected at more than 1,600 million km away from the Earth, 71 years after it was last sighted in 1911.

Plans to observe the comet as it approaches have been underway throughout the world for several years now. The European Space Agency intends to send the Giotto spacecraft to within a few hundred kilometres of the comet's nucleus. The USSR will send two Venera spacecraft which will fly by the nucleus at a distance of 10,000 km, while the Japanese Planet-A will pass within 100,000 km.

All of the encounters will take place in March 1986 when Halley is some 145 million km away from the Earth.

In addition to the space missions, a world-wide programme of observations using ground-based telescopes has been set up: the International Halley Watch (IHW).

Giotto will be launched by an Ariane 3 rocket from Kourou, French Guiana, in the first half of July 1985 into a geostationary transfer orbit with a perigee of 200 km and an apogee of 35,700 km. A few days later the spacecraft's own rocket motor will be fired and the spacecraft will be injected into its heliocentric transfer trajectory to the comet. Eight months later, at midnight GMT on 13 March 1986, Giotto will encounter Halley's Comet.

The European probe will carry more than 10 experiments, among them a camera for colour images of the comet coma and the nucleus, three spectrometers for measuring the composition of the gas and dust in the cometary atmosphere, and various plasma experiments for studies of the interaction between the solar wind and the comet. Halley's Comet has a retrograde orbit, which means it orbits around the Sun in the opposite direction to that of all the planets and Giotto. This results in the very high flyby velocity of 69 km/s which means that Giotto must carry a dust shield to withstand the impacts of dust grains at these extreme velocities.

The two Soviet spacecraft will also carry a complex but somewhat different scientific payload, including cameras. The first will encounter the comet on 8 March, a few days before Giotto, while the second is foreseen around 16 March 1986. The Japanese encounter will also take place around 8 March.

Owing to the likelihood that Halley's Comet will prove to be a disappointing object when viewed from the Northern Hemisphere, if it can be seen at all, the Society plans to organise a trip to South Africa to view the comet from the Southern Hemisphere. Present indications are that the most favourable time will be the first week in April 1986. The provisional itinerary is: flight from London to Johannesburg, four nights in Johannesburg, three day tour of Kruger National Park, flight to Port Elizabeth, three day tour of the Garden Route from Port Elizabeth to Cape Town, four nights in Cape Town, and return to London *via* Johannesburg. There will be plenty of opportunities for viewing the comet.

The approximate cost at present day prices is £1,000. This includes all air and coach travel, accommodation in first class hotels, plus breakfast and dinner on coach-travelling days.

Forms for provisional registration are now available from the Executive Secretary. Please enclose a stamped addressed envelope.

A deposit of £30 per person is required, fully refundable on written cancellation at any time up to December 1985.

Society Educational Tours

Halley's Comet – April 1986 – 14 days duration

PERSONAL PROFILE

MITCHELL R. SHARPE

We begin this month an occasional series of personal accounts from space personalities of their lives and careers in astronautics. Mitchell Sharpe is familiar to BIS members as the author of many *Spaceflight* articles and as the Editor of our "Astronautics History" Journal. His career as a writer with NASA included Apollo's hey-day in the 1960's; working with von Braun was obviously an impressive experience . . .

Introduction

Born on 22 December 1924, in Knoxville, Tennessee, among the foothills of the Smokey Mountains (in the deep valleys and remote hollows of which can still be heard the English of Elizabeth I), I remember only one feature of it almost six decades later. In the centre of town there was a market square and hall selling meat, vegetables and bread in those halcyon days before supermarkets. Everything was fresh; nothing was frozen except one's nose and toes when at Christmas time the stall-holders huddled over braisers selling chestnuts (*American* chestnuts, now extinct, but at the time the largest, sweetest and best in the world).

In 1942, I entered the Alabama Polytechnic Institute, enrolling in chemical engineering, a decision which later proved to be an academic disaster. Hardly settled in, I was conscripted into the Army for World War II. Having spent six months at the university learning everything about field artillery, in the Reserve Officers Training Corps (ROTC), predictably I was sent into the infantry as a rifleman.

My career during the war was, if nothing else, undistinguished. The only award I received was the Good Conduct Medal, and that because of an administrative technicality. A member of the 87th Infantry Division, I served with the Third US Army in France, Belgium, Luxembourg and Germany. Before going to the Continent my infantry company was stationed briefly in Congleton, England (but I preferred the pubs in Macclesfield).

Back to College

Back in the USA in 1946, I returned to university. At the end of the first academic quarter, I was called to the office of the dean of the college of chemical engineering.

"Mr. Sharpe, have you any idea at all what the slide rule is?"

"Yes sir! Indispensable in chemical engineering."

"Then why in the history of the college of chemical engineering are you the first student to fail the course in its operation and application?"

Thus drummed out of chemical engineering, I found a home in the college of liberal arts: English literature and journalism. In 1949, with a BS degree I walked back into the US Army. But that time there was a difference. I went to Korea as Second Lieutenant Sharpe of the field artillery, having had the foresight to earn a commission in the ROTC. Another war; no medals (officers are not eligible for the Good Conduct Medal, which says something about the US Army); no mention in dispatches. However, I did ride to work in a jeep with a driver instead of walking to it with a rifle and pack. Back to the university for an MA degree in 1954.

So much for the exciting part of my life.

In 1955, I became a technical writer and editor at the US Army Rocket and Guided Missile Agency at Redstone Arsenal in Huntsville, Alabama. I worked there for five years writing operation and maintenance manuals on solid-propellant rockets such as Honest John, Little John and Lacrosse. I also supervised the preparation of similar manuals on anti-aircraft missiles such as Nike Ajax, Nike Hercules and Hawk. A few miles away on the arsenal was the US Army Ballistic Missile Agency. It was staffed in part by a group of some 125 former German scientists and engineers who had developed the V-2 missile during World War II. The boss was an affable, blond, young man named Wernher von Braun. With a subtlety that became a trademark of his managerial practices, he had to keep in line "his team" when they complained that developing the Redstone missile was "reinventing the V-2". As he had done at Peenemünde, during World War II, he encouraged certain individuals to look at designs of scientific satellites and multistage rockets capable of putting man into space. All of this was done even though the US Army had no explicit space interest at the time.

I met von Braun in 1956, when a group from Rocket City Astronomical Society approached him with the idea of publishing *Space Journal*, a magazine on astron-

autics written for the man in the street. Von Braun, as president of the society, had helped to construct its observatory in Huntsville. While his role was supervisory in the main (pointing to things that needed done with a cold can of Schiltz beer in his hand), he was nevertheless a man who got things done. His endorsement of *Space Journal* notwithstanding, it lasted for only two years.

Wernher von Braun, despite the satire of Tom Lehrer (Tom who?), was one of the most remarkable men I ever met. For 20 years I worked for and with him, having transferred from the US Army Rocket and Guided Missile Agency to the newly-established Marshall Space Flight Center, which von Braun headed in 1960.

As the Saturn launch vehicle project developed at MSFC, von Braun and particularly Arthur Rudolf, the Saturn 5 manager, became worried about the growing lack of attention to quality and reliability among its prime contractors and literally thousands of subcontractors and suppliers. As a result, Rudolf asked Dr. Preston Farish and myself, of his staff, to look into ways of remedying the situation. At that time, in the early 1960's, the US Army Missile Command at Redstone Arsenal had instituted an imaginative and innovative *Zero Defects* programme. Its aim quite simply was to increase quality and reliability by motivating employees to reduce defects to zero.

After having attended a course in the Army's Zero Defects, I began adapting it to the special needs of the Saturn project in a programme called Manned Flight Awareness (MFA). The result was highly successful, largely because of the enthusiastic participation of the Apollo astronauts who, admittedly, had a vested interest. Special films and slide shows were presented in such diverse companies as a manufacturer of storage batteries for the Saturn 5 guidance unit and the cargo handling crews of a major airline. Competition among production units within aerospace plants were encouraged by company management, and awards were made by NASA, which by the mid-1960's had adopted the MFA programme for all of its Apollo centres. Most successful and sought-after of these awards was the Snoopy medal. It was the astronauts' personal award to an individual who had done something "beyond the call of duty." Put another way, it was the VC of the MFA programme. Charles Schulz, the shy but enthusiast of space who draws "Peanuts", had designed especially for NASA use a small silver pin with Snoopy in a spacesuit. Each was awarded by a personal letter from an astronaut.

Another highly motivating feature of the MFA programme occurred with the launch of each Saturn 1B vehicle or Apollo mission. All prime contractors and designated subcontractors or suppliers sent its MFA honourée (and spouse) to see the launch and to be guests of honour at a special reception which included astronauts, NASA top management, movie and television stars, and (always) von Braun. I can remember, wickedly, including among the special guests a self-certified British witch living near the Cape. She must have cast some sort of spell since she proved to be as popular as the astronauts and von Braun.

With the end of Apollo, NASA bowed out of manned space flight for several years. Skylab and Apollo Soyuz were more or less afterthoughts to use up left-over hardware. With this decline there was no need for the MFA programme. Reliability and quality in the Space Shuttle were left to "in-house practices" largely.

By the mid-1970's, the American civil space programme and NASA had become somewhat atrophied. I had had enough. In 1974 I retired and became a free-lance technical writer working, as it suits me, in the aerospace and energy technology fields.

Mitch Sharpe, far right, with the Apollo 15 astronauts (from left: Irwin, Worden and Scott) during an awards ceremony after the mission.

THE PRIVATE ASTRONAUTS ARE COMING!

By Anne van den Berg

As the 1980's unfold, the amount of activity in space will grow. It is even possible that private operators will be flying Space Shuttles, creating a demand for qualified flight crews and support personnel. To satisfy this demand, the world's first commercial Spaceflight Ground School has opened its doors. Its training programme is run by The American Society of Aerospace Pilots, a non-profit organisation based in Illinois.

Introduction

The problem of finding tomorrow's space pilots is increasingly pressing, according to ASAP. Traditionally, NASA has relied on test pilots, engineers and scientists to perform their missions. If the Shuttle launch rate were increased to one flight per week, today's pool of such experts would barely suffice. According to David Koch, chairman of ASAP, a total of 300 Shuttle pilots will be needed by 1985 (100 military, 100 NASA, and 100 civilian commercial pilots). By 1987, he thinks the need will have risen to 1,000. There are 40,000 jet airliner pilots in the United States today; a pool from which a suitable group can be trained for Space Shuttle operations.

ASAP's Background

ASAP began as a subdivision of the United Airlines section of The Air Line Pilots Association (ALPA) under the guidance of David Koch, himself a UA pilot. Expecting commercial space operations in the near future, Koch and his group of interested pilots found a widespread interest among professional pilots. In September 1981, ASAP was incorporated with Koch as national chairman.

ASAP has four categories of membership: full, associate, corporate and honorary. The future space pilots will come from among the full members, who are all commercial pilots. They must have instrument and multi-engine ratings, as well as 2,000 hours of flight experience as a flight deck crew member. ASAP's associate membership is divided into three categories: pilot, general and student. Pilot in this case means a FAA private pilot certificate. Associate members looking towards an eventual career in space may follow the school's courses, but will not receive certification as Aerospace Pilots.

The School

ASAP's Ground School offers practical courses on various aspects of space flight, stressing Space Shuttle operations. The material comes mainly from NASA's own Astronaut Candidate Program, shaped by training experts from the United Airlines Flight Training Center in Denver, Colorado. The present basic curriculum is divided into nine courses; these are subdivided into modules, giving a total of approximately 60 lessons. Those who aspire to space pilot status must enrol in the full course:

1: Introduction (3 modules)
2: Spacecraft Design (5)
3: Space Navigation (10)

4: Orbital Mechanics (14)
5: Technical Theory (3)
6: Mission Planning (6)
7: Spacecraft Systems (8)
8: Avionics/Data Processing (6)
9: Payloads (3)

Additional courses are under development. These include scuba diving, sailplane piloting, experience in high-altitude chambers and aerobatics, as well as survival training for land, water and space.

The courses are designed for individual study. Each student's performance and progress will be tested *via* computer terminals, distributed throughout US computer centres, and available at a variety of scheduled times. The results will be recorded by a sophisticated educational computer program called PLATO.

ASAP's greatest wish is to include a Space Shuttle simulator. Simulators are very expensive, however, and ASAP can afford one only with a membership base of about 2,000.

Conclusions

Some US space experts feel that ASAP's ambitious programme is somewhat premature. Still, their activities may allow pilots to fly in space, according to William Backus, a planning officer at the Kennedy Space Center. There are plans to build a fifth Space Shuttle; the Space Transportation Company of Princeton in New Jersey, wants to put up the money. In any case, the course offered by ASAP is ideal for science reporters, corporate people and others who need detailed knowledge about space operations.

Even if ASAP's dreams were to be fulfilled, it is still unlikely that they will have the first private space pilot. Robert Truax of Saratoga in California plans to send a passenger 80 km high in his own X-3 rocket sometime this year.

Acknowledgement

The author would like to thank Peter Hesselberg for his assistance in preparing this article.

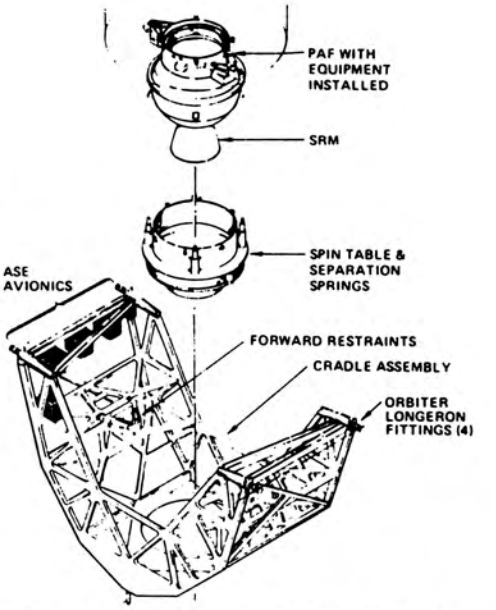
SATELLITE HANDLING FOR THE SHUTTLE

By Gerald L. Borrowman

Introduction

The advent of the Space Shuttle has introduced a new level of complexity to the cargo services and integration operations needed for each launch. Expendable launch vehicles, such as the Delta, have traditionally provided transportation to a given orbit and separation, but only for a single satellite. However, the use of the Shuttle for carrying a mixture of payloads on a single mission forces planners to ensure that the satellites and/or fixed payloads are compatible. This requires consideration not only of the launch environment but also of the thermal environment encountered during long stays in space. In addition, the payloads have to be prepared to withstand the rigours of a mission abort. Command and data services must be provided through the Orbiter systems, and a lengthy mission would require Orbiter-supplied electrical energy until payload separation. For an attached sortie payload (ie it is not released as a satellite), the integration becomes even more complex in that the Orbiter is required to provide cooling and additional command and data services, as well as extensive astronaut involvement.

In order to manage this complex series of interactions, offices have been created at the Johnson and Kennedy Space Centers. They deal with the Department of Defense and other contractors to identify and analyse the problems of mixed cargoes, developing guidelines to help payload designers produce compatible hardware.

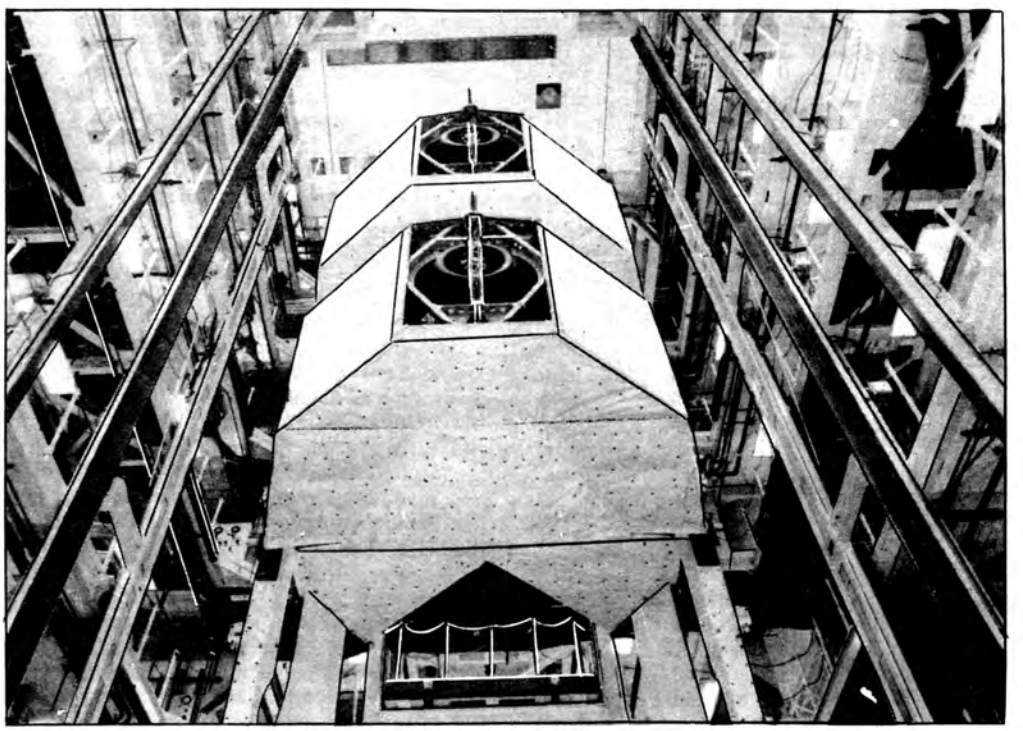


Two satellite cradles were carried on the fifth Shuttle Mission last November (see below).

Payload Preparation

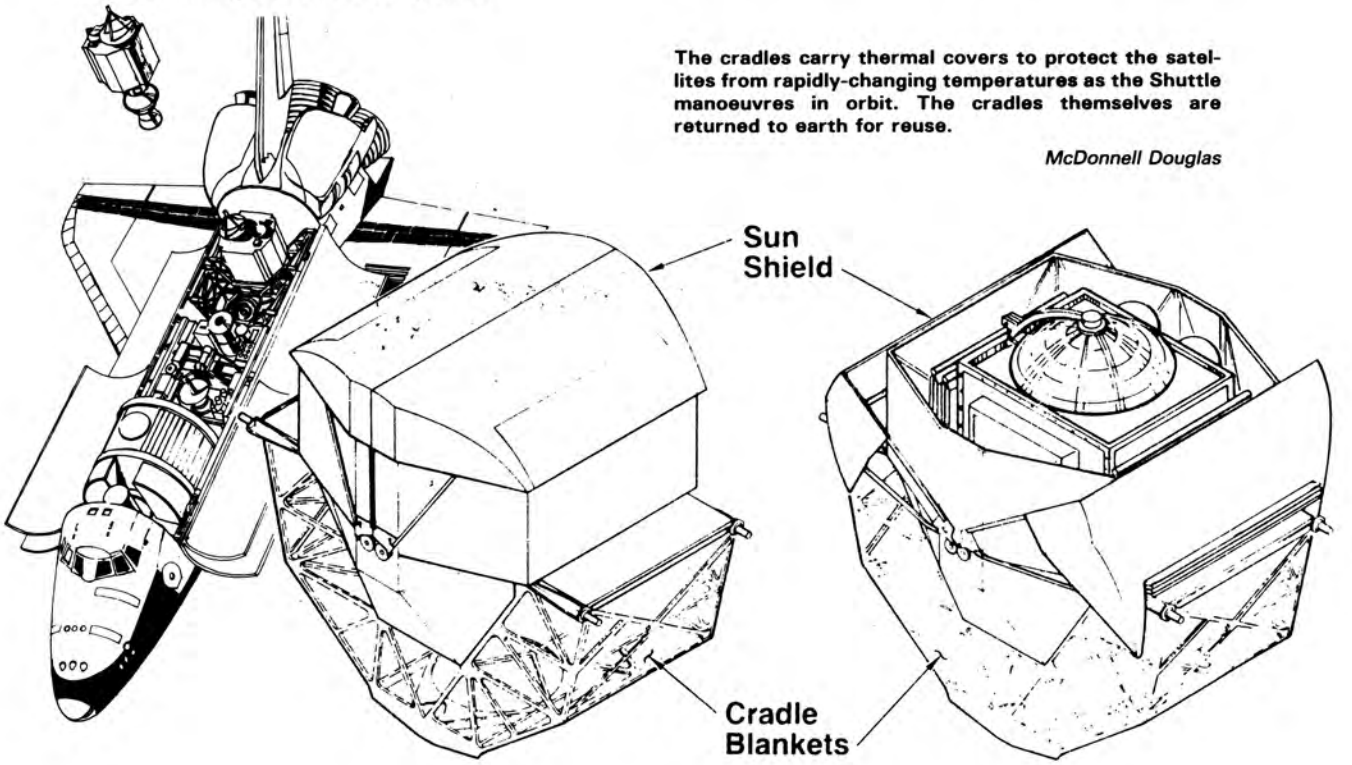
In earlier launch vehicle programmes, the performances and services have generally improved with the increasing maturity of the launcher. The planned rate of up to 40 Shuttle missions per year will have a major effect on cargo processing at the Kennedy Space Center. The high launch rate is predicted on a turnaround time of two weeks on the ground for each Orbiter (possibly an optimistic figure), a factor that, in turn, requires a payload processing capability both efficient and economical.

Payloads for launch from the Kennedy Space Center can be divided into two basic groups: those horizontally integrated and those vertically integrated. The type of payload dictates whether it should be installed in the cargo bay in the Orbiter



The two STS-5 satellites in the vertical processing facility before insertion into the handling canister for the trip out to the pad.

NASA



The cradles carry thermal covers to protect the satellites from rapidly-changing temperatures as the Shuttle manoeuvres in orbit. The cradles themselves are returned to earth for reuse.

McDonnell Douglas

Processing Facility (OPF) or at the launch pad. The main consideration is the type of hazardous operations to be performed. Certain jobs, such as fuelling a satellite, cannot be performed in the OPF, and some payloads must be installed at the launch pad.

Horizontally integrated payloads, for example Spacelab, are received at, assembled, and checked out in the Operations & Checkout (O&C) Building. Following build-up of the payload "train", the Spacelab elements will be transferred to the Spacelab Integration Test Stand for mating with the Spacelab Module or Igloo. Systems testing is then conducted and the assembly moved to the horizontal Cargo Integration Test Equipment (CITE) stand. The simulated Orbiter-to-cargo interface testing is then conducted.

Spacelab is then installed in the environmentally-controlled payload canister and transported to the OPF and installed in the Orbiter cargo bay. The craft is then towed to the Vehicle Assembly Building, mated with its External Tank and Solid Rocket Boosters on the Mobile Launch Platform, and then rolled out to the launch pad. On the pad, access to the payload would be by way of opening the cargo bay doors.

Preparation of vertical payloads involves facilities currently used as spacecraft checkout areas for unmanned launchers. Most vertically integrated payloads are automated spacecraft, designed to operate in higher orbits than the Orbiter can reach. A typical payload will consist of two spacecraft, each with an attached solid propellant upper stage and a built-in apogee kick motor.

Such a spacecraft arrives at the Kennedy Space Center and is met by a developer/builder team. The teams move the craft to a Processing Facility and begin assembly and checkout operations. This can take from 30 days for a simple communications satellite to four months for a complex interplanetary explorer. When the spacecraft is ready, the test and checkout team takes it to one of two Explosive Safe Areas, ESA 60 or the Delta Spin Test Facility. The explosives, pyrotechnics, and certain volatile propellants are added here. The Solid Spinning Upper Stage (SSUS-D) is also attached here and the assembly spin-tested for balance. Larger upper stages such as the SSUS-A or the Inertial Upper Stage are mated at the next stage in the process: the Vertical Processing Facility.

The complete cargo, two or more spacecraft, attached upper stages, and any in-flight support equipment, is then checked for mechanical fit and electrical compatibility with the Shuttle cargo bay. The integrated payload is then loaded into the payload canister.

The canister is taken directly to the launch pad by a specially-designed transporter and transferred into the spacecraft handling room in the Rotating Service Structure. The RSS forms a seal against the Shuttle cargo bay and the payload can be fixed in place in a controlled environment.

Payload designers cannot commit their spacecraft to a Shuttle-compatible design unless they can be sure that the Shuttle will be operable when they need to launch their satellites. What would fit in the Shuttle cargo bay might not fit atop an expendable launcher.

One case in point is the Air Force's Satellite Data System spacecraft. The design has been changed to "short and fat" to use the cargo bay space more efficiently.

Cargo manifesting for the Air Force's Vandenberg site will be complicated by the differing launch time requirements of the spacecraft and the low frequency of missions flown. Many of the satellites presently orbited from Vandenberg, such as meteorological and Earth resources satellites, have specific mission objectives, such as obtaining weather data at specific times of day (morning/evening), studying landforms which require shadows (early morning or late evening) to highlight surface features, infrared sensing requiring night coverage, or conducting crop inventories requiring maximum solar flux (near noon). These constraints pose a major problem for scheduling Shuttle flights from the west coast.

Acknowledgements

The author wishes to express his appreciation to Donald S. Edgecombe, Battelle Colmbus Laboratories; Roger Chamberlain, Martin Marietta Aerospace; Lawrence G. Williams of the Johnson Space Center; John J. Neilon, Manager, Cargo Projects Office, John F. Kennedy Space Center.

AMERICA'S HONOURED ASTRONAUTS

By Philip W. Snowdon and Roger F. D. Wheeler

American astronauts have always received honours as a result of their activities in space. This recognition has often been in the form of medals and citations but in many cases a tangible memorial has been granted with the naming of a school, a museum or some other building. This article deals with many of the permanent sites of this kind, most of which are in the United States.

Kennedy Space Center

During US Space Week (16–24 July) in 1974, at the Kennedy Space Center in Florida the anniversary of the first manned landing on the Moon was commemorated when astronauts Armstrong, Aldrin and Collins unveiled a plaque at Launch Complex 39A to dedicate the site as a National Historical Landmark.

Ten years previously, LC 14 had received the Project Mercury Monument. The 13 ft tall, 1250 lb astronomical symbol for the planet Mercury inlaid with a "7" is made of the same stainless steel used for the Atlas rockets that launched four men into Earth orbit during 1961 to 1963. Dedicated on 10 November 1964, the monument was donated by the General Dynamics Corp., builders of the Atlas. On the base is an inscribed bronze tablet and a 2½ ft diameter medallion showing the seven Mercury astronauts in high-relief. Inside the base is a time capsule, intended to be opened in the year 2464, containing film and printed matter concerning John Glenn's pioneering flight in *Friendship* 7 on 20 February 1962. Also, at the Visitor Information Center of KSC is a memorial to deceased American astronauts and Soviet cosmonauts.

The Moon

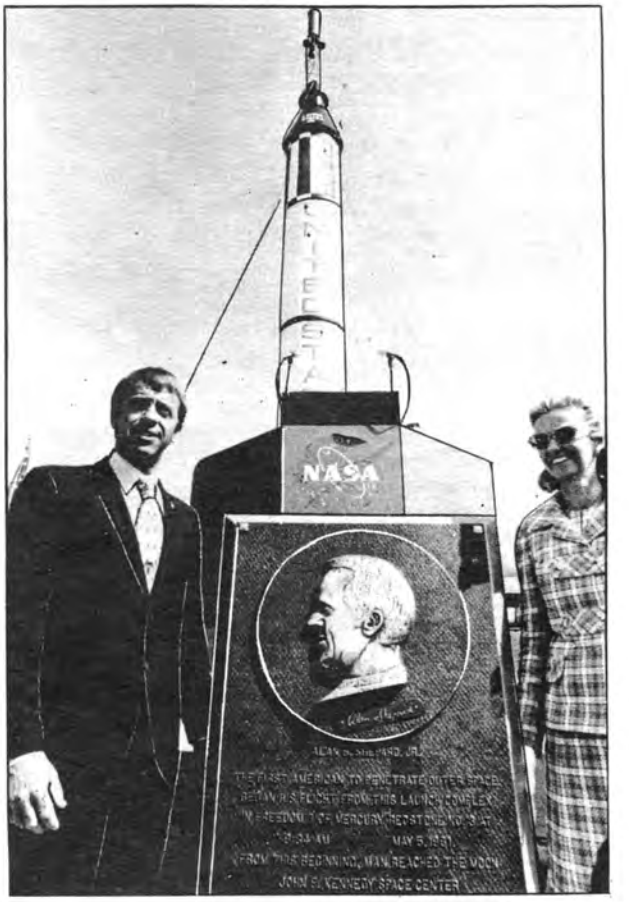
The Moon also carries reminders as a result of the Tricentennial Assembly of the International Astronomical Union held in Brighton, England in 1970. At this gathering, astronomers named lunar craters for 513 people. Craters on the Moon's far side were named for the crews of Apollo 1 (Virgil Grissom, Edward White II and Roger Chaffee); Apollo 8 (Frank Borman, James Lovell and William Anders) and another for the Apollo programme itself. Also mentioned is X-15 rocket aircraft test pilot Joseph Walker, who died in 1966. On the Moon's near side there are three craters near the Sea of Tranquility named after Armstrong, Aldrin and Collins.

During the almost 67 hours they spent on the lunar surface at the Hadley–Apennine site in July 1971, Apollo 15 astronauts David Scott and James Irwin left a small plaque in the soil to commemorate the eight astronauts and six cosmonauts who had lost their lives. They were Charles Bassett, Roger Chaffee, Theodore Freeman, Edward Givens, Virgil Grissom, Elliot See, Edward White and Clifton Williams. A tiny man-like sculpture lies in front of the plaque.

The Apollo 8 crew members are noted on a plate at Hickam AFB at Honolulu in Hawaii. Installed at the base's Operations Building it reads; "From this marker at a distance of 545 feet in a south-easterly direction, the Apollo 8 astronauts Col. Frank Borman, Capt. James Lovell and Lt.-Col. William Anders touched soil at 14:37:35 after their historic flight around the moon 28 December 1968."

Schools

One of the educational influences of manned space flight is recorded across North America in the naming of schools after individual astronauts. There is a Gemini Junior High School in Niles, Illinois, and schools bearing the Apollo title in Des Plains, Aledo and Carbon Cliff in Illinois and in Tucson, Arizona. A different educational approach can be found in the Astronaut Memorial Hall at the Cocoa campus of the Brevard Community College in Florida. The Hall, dedicated in June 1976 at a ceremony attended by John Young, is part of an educational astronomical and solar observatory and planetarium teaching space sciences. A section of the Hall is a semi-museum housing John Glenn's Mercury training capsule and small items as well as portraits of the astronauts. The outdoors exhibits include a Vanguard and a Jupiter booster.



Ten years after his epic flight into space, Alan Shepard unveiled a plaque at Launch Complex 5/6, site of the Mercury launches. Three months before the ceremony, Shepard had been on the Moon as part of the Apollo 14 mission.

NASA

In California there stands the International Aerospace Hall of Fame which is part of the museums complex in Balboa Park, San Diego. Founded in 1963, the IAHF seeks to trace the history of aviation and space travel through the story of the men and women directly involved. A number of astronauts have their portraits in the Hall of Fame Gallery: Edwin Aldrin, Neil Armstrong, Michael Collins, John Glenn, Walter Schirra and Alan Shepard.

Moving to the east, to New Mexico, there exists an establishment similar in outlook to the IAHF but independent of it. This is the International Space Hall of Fame at Alamogordo [1]. Opened in 1976, the ISHF has many space-related exhibits but it is dedicated to the men and women from many countries who have contributed to advances in space research. Astronauts

Astronaut Neil Armstrong in the cockpit of the Lunar Module *Eagle* after returning from the Moonwalk on 21 July 1969.

NASA

Apollo 11 astronauts (left to right: Aldrin, Collins and Armstrong) inspect a lunar sample several months after their mission in July 1969. All three men retired from the space programme.

NASA

Buzz Aldrin's home for many years, Princeton Place in Montclair, New Jersey.

John E. Chance

featured are, with their year of induction, Neil Armstrong and John Glenn (1976), Michael Collins and Harrison Schmitt (1977), Edgar Mitchell (1979), Thomas Stafford (1980) and Alan Shepard, Virgil Grissom, Scott Carpenter, Walter Schirra and Gordon Cooper (1981).

As with the schools theme, there are a number of military sites named for individuals. At the US Naval Academy at Annapolis in Maryland there is an exhibit in the Academy's public museum on its alumni who became astronauts. The Navy also commemorated some of the astronauts who graduated from its Naval Test Pilot School at Patuxent River in Maryland when, in 1974, Officers' and Enlisted Men's family housing complexes at the Naval Air Station were named as Shepard Terrace, Chaffee Court, Carpenter Park, Conrad Heights, Lovell Court, Glenn Vista and Schirra Circle.

Apollo 1

The crew of Apollo 1 (Grissom, Chaffee and White) lost their lives during a launch test on the pad at Cape Kennedy on 27 January 1967. The Department of Oil Properties of the City of Long Beach in California built four oil-drilling islands in San Pedro Bay during 1965–1966. Three of the islands were later named for Grissom, Chaffee and White and the fourth for T. C. Freeman.

In Alabama in 1969 the Huntsville City Board of Education named three new schools in Madison County, calling them Grissom High School, White Junior High School and Chaffee Elementary School. They were all dedicated by Wernher von Braun and astronaut Russell Schweickart on 7 December 1969. A year after the Apollo 1 fire the American Museum-Hayden Planetarium in New York City unveiled a plaque at the planetarium. The bronze tablet was presented by a group known as "Friends of Man in Space" and it carries Grissom's prophetic words ... "If we die, we want people to accept it. We are in a risky business and we hope that if anything happens to us it will not delay the program. The conquest of space is worth the risk of life."

Grissom and Chaffee are buried at the Arlington National Cemetery in Virginia, while Edward White rests at the West Point Military Academy in New York.

THE ASTRONAUTS

Aldrin

"Buzz" Aldrin was born in Montclair, New Jersey in 1930. After his return from the Apollo 11 mission, Montclair celebrated "Buzz Aldrin Day" on 6 September 1969 and, along with other tributes, the Rotary Club of Montclair placed an 840 lb boulder carrying an inscribed plaque in front of the original home of the Aldrin family in Princeton Place. The volcanic "featherstone" rock was chosen because it looks similar to the material found on the Moon. There are also two schools in the State of Illinois, the Edwin Aldrin Elementary in Schaumburg and the Aldrin Junior High in Barstow.

Armstrong

Ohio-born Neil Armstrong is well recognized in and around his home town of Wapakoneta. Roads leading to the town are posted with signs proclaiming: "WAPAKONETA. Home of Neil Armstrong. First Civilian Astronaut on the Moon." There is also a Neil Armstrong Drive. Probably the greatest tangible honour given to him is the naming of the Armstrong Air and Space Museum at Wapakoneta. Opened on 20 July 1972, the contemporarily-designed museum has on show objects connected with the astronaut's career. These include an aircraft he has flown, the Gemini 8 spacecraft he shared with Dave Scott in 1966, and his Gemini and Apollo space suits. South of town, the Auglaize County Airport Authority operates the Neil Armstrong Airport at New Knoxville. There are at least six schools, including Neil Armstrong Elementary's in Hoffman Estates and Richton Park, Illinois, San Antonio, Texas and Rochester, New York; Armstrong Elementarys in Chicago, Illinois, and a Neil Armstrong Junior High in Jacksonville, Illinois. In June 1970 Armstrong and his wife participated in ceremonies in Rome during which Mrs. Armstrong christened a Boeing 747 belonging to the Italian state carrier, Alitalia, as "The Neil A. Armstrong". The couple later flew in the aircraft from Rome to New York.

Bean

Al Bean, the Apollo and Skylab astronaut, was born in Wheeler, Texas on 15 March 1932 and the township has recognised his space achievements by naming Alan L. Bean Boulevard after him.

Borman

Frank Borman was born in Gary, Indiana on 14 March 1928, but his family moved to Tucson, Arizona while he was still a youngster. The town of Gary decided to declare 14 January 1966 to be Frank Borman Day and an area between 7th and Madison Streets was named Borman Square Park. Also on this day a section of Interstate Highway 94, the Tri-State Expressway running through Lake County at Gary, was named the Frank Borman Expressway by the Indiana General Assembly. The section was opened on 2 November 1972. In Arizona, the Frank Borman Junior High School in Phoenix was named in March 1968, while further south in Tucson the Frank Borman Elementary School was opened on the Davis-Monthan AFB. Borman passed through the US Military Academy at West Point and one of his space suits is on display in the Academy's museum.

Brand

Vance Brand is a native of Longmont, Colorado and at the Longmont Pioneer Museum is a semi-permanent exhibit area, "The Vance Brand Space Gallery", which houses items used by the astronaut in connection with his flight for the Apollo-Soyuz Test Project in 1975. Also at Longmont, the Skyline High School has a Vance Brand Auditorium.

Carpenter

Scott Carpenter was born in Boulder, Colorado and the city has honoured him with a 21 acres area called Scott Carpenter Park, an Olympic-sized Scott Carpenter Swimming Pool and the Aurora 7 Elementary School (named after his Mercury spacecraft).

Carr

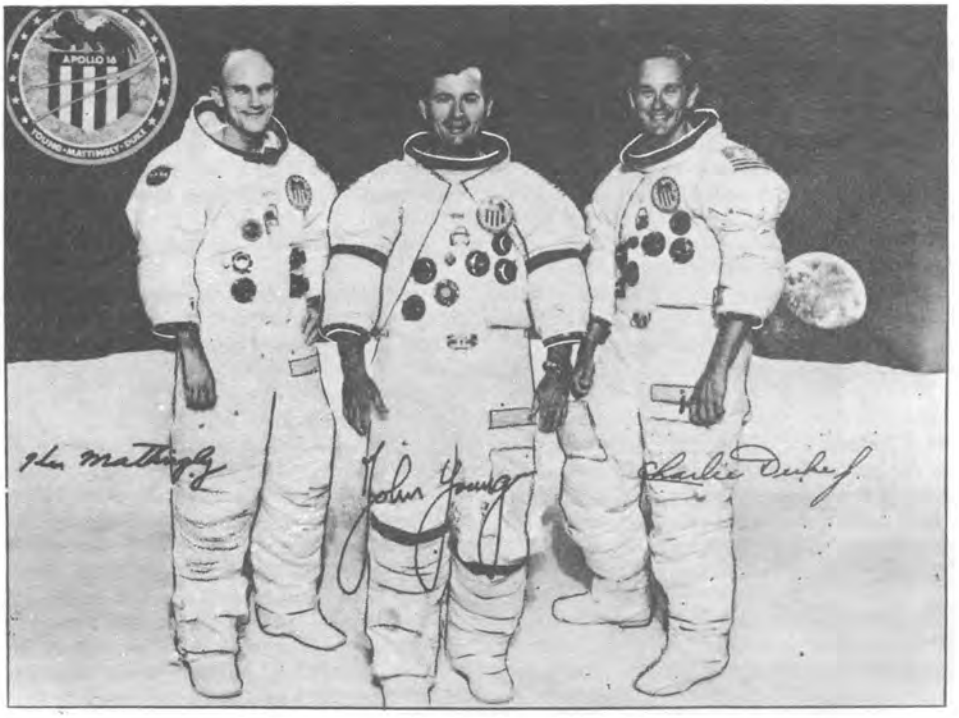
Gerry Carr was born in Denver, Colorado but he was raised in Santa Ana, California where, on 9 July 1974, the local Board of Education changed the name of a local school to the Gerald P. Carr Intermediate School. The dedication ceremony took place on 4 October 1974.

Cernan

Gene Cernan is a native of Chicago, Illinois. In his hometown area of River Grove, the Eugene A. Cernan Space Center was dedicated at Tirton College campus on 23 May 1974. A statue of the astronaut in a space suit, unveiled by his mother, stands at the entrance to the building which houses science classrooms, laboratories and a "sky theater". In Texas, in the town of Kirby, on the outskirts of San Antonio, there is a Cernan Road.

Chaffee

Roger Bruce Chaffee lost his life in the Apollo 1 pad fire in 1967. His hometown of Grand Rapids, Michigan has honoured him with the naming of Roger B. Chaffee Boulevard, an industrial drive on the south side of the town. More importantly he is remembered in the Roger B. Chaffee Planetarium, an 87



The Apollo 16 crew, left to right: Ken Mattingly, John Young and Charles Duke. Young later flew the first Space Shuttle orbital mission and has been named to command the Spacelab 1 flight in September. Mattingly commanded the STS-4 mission in June 1982 and will command STS-10 in December.

NASA

seat facility attached to the Grand Rapids Public Museum. The dedication of the planetarium took place on 19 May 1967, and was addressed by Chaffee's good friend, astronaut Eugene Cernan. Earlier in the month Cernan had spoken at another gathering, held in Texas, when the members of the Nassau Bay Garden Club at Clear Lake, near the Lyndon B. Johnson Space Center, planted a memorial cedar tree for Roger Chaffee. The naming ceremony was held on 7 May 1967, in the presence of Martha Chaffee and her children. The cedar tree was to be decorated as a Christmas tree each year. Chaffee was an alumnus of Purdue University at West Lafayette, Indiana, graduating in aeronautical engineering in 1957. Shortly after his death the decision was made by the Board of Trustees to name the library office building of the University's Jet Propulsion Center, erected in 1966, the Roger B. Chaffee Hall. This was done on 2 May 1968, by NASA's Dr. George E. Mueller. Four-year scholarships were also provided for the two children of Martha and Roger Chaffee.

Collins

Michael Collins was born in Rome, Italy on 31 October 1930. There is a recognition plate on the house in which he was born in the Via Tevere. In the United States in Schaumburg, Illinois is the Michael Collins Elementary School.

Freeman

T. C. Freeman was born in Haverford, Pennsylvania on 18 February 1930. He lost his life in a T38 jet crash at Ellington AFB, Texas on 31 October 1964. The Captain Theodore C. Freeman Memorial Library of the Houston Baptist University in Texas was brought into being on 21 January 1965, and contains books concerned with aerospace and related fields. Freeman is interred at the Arlington National Cemetery in Virginia.

Garriott

The town of Enid, Oklahoma, where Owen Garriott was born on 22 November 1939, has remembered his career by placing a monument in front of his parents' house and by naming the main east-west road through the town "Owen K. Garriott Road". In addition, the shell of a back-up Apollo CM was donated by NASA and is now erected in a community park.

Givens

Edward Givens Jnr. was born in Quanah, Texas on 5 January 1930. He died in a car accident near Houston on 6 June 1967. On 5 March 1977, the Edward Givens Memorial Room at the Hardeman County Heritage Museum in the town was dedicated by fellow astronaut Thomas Stafford. In Missouri at Keesler AFB is a street named after astronaut Givens.

Glenn

John Herschel Glenn Jnr. was born in Cambridge, Ohio in 1921 but he and his family moved the short distance south to New Concord in 1923. The township has carried out a number of changes in his honour so that there exists Friendship Drive, which was once Bloomfield Road where the Glenn Family lived, and also the John Glenn High School. The Physical Education building of New Concord College is named after him and Route 40 between Zanesville, west of New Concord and Cambridge is known as the John H. Glenn Memorial Highway. There is also a John Glenn Elementary School in San Antonio, Texas. Small items carried by the astronaut aboard his Mercury craft *Friendship 7* are on display at the USAF Museum, Wright-Patterson AFB near Dayton, Ohio. On 20 February 1980, Glenn and his wife Annie dedicated the Mercury Monument at Cape Canaveral. The marker was donated by the American Monument Association.

Grissom

Virgil Grissom was born in Mitchell, Indiana on 3 April 1926. He became America's second man in space on 21 July 1961. Following this flight he was honoured by the people of Newport News, Virginia with the opening of the Virgil I. Grissom Library in Denbigh. "Gus" Grissom lost his life with his two colleagues on 27 January 1967, in the Apollo 1 fire. He had graduated from Purdue University at West Lafayette, Indiana in 1950. Eighteen years later, after remodelling at the campus, the Civil Engineering Building was renamed as the

Virgil I. Grissom Hall, dedicated by Dr. George Mueller on 2 May 1968, along with Chaffee Hall. At the time of his death, Grissom was a Lieutenant Colonel in the USAF and the Service paid its tribute when, on 13 February 1968, the Air Force Chief of Staff announced the decision to change the name of Bunker Hill AFB near Peru, Indiana to Grissom AFB. The change took effect from May 1968.

The township of Mitchell has remembered its son in many ways. On 21 July 1971, just ten years since his first space flight, the Virgil I. Grissom State Memorial was dedicated. Located in Spring Mill State Park near Mitchell, the Memorial features mementoes of his life, including the Gemini 3 craft in which he flew with John Young. The school at Mitchell is now the Virgil I. Grissom High and in October 1981, outside Mitchell City Hall, a 34 ft tall Indiana limestone rocket, pointing towards the stars and bearing an inscription in tribute to the astronaut was dedicated. There is also a Grissom Avenue. Named schools outside the State of Indiana include the V. I. Grissom Elementary in Houston, Texas, dedicated 5 May 1968; V. I. Grissom Junior High, Tinley Park, Illinois and Grissom Elementary in Chicago. There is a Grissom Road in Kirby, near San Antonio. Grissom also has a lunar crater named after him and there is also another astronomical connection: in early 1981 a newly discovered asteroid of five to ten miles diameter was named "Grissom" and given the catalogue number 2161 (from the date of his Mercury flight).

Haise

Apollo 13 Lunar Module Pilot Fred Haise hails from Biloxi on the Gulf coast of Mississippi. After the return of the crew of the ill-fated mission on 17 April 1970, signs went up in the street where the Haise family lived proclaiming it "Haise Street", the name it now officially carries. Also, the eastern portion of Highway 90 along the coast was named Fred Haise Boulevard. The Fred Haise Room in Gallery 1 of the Magnolia Hotel Museum in Biloxi, was opened in the autumn of 1976 and contains items connected with the astronaut, including his Apollo 13 suit. There are also pictures and memorabilia in the Mayor's office and in the lobby of City Hall.

Kerwin

Born in Oak Park, Illinois in 1932, Skylab astronaut Dr. Joe Kerwin returned to his home town in 1973. In accord with the festivities at that time, the Oak Park Public Library made a special purchase of space-related books and connected them with him by placing a recognition card in each.

Mattingly

Ken Mattingly was born in Chicago, Illinois in 1936, but he grew up in Hialeah, Florida. Here, at the Hialeah-Miami Lakes High School on 13 October 1977, the ceremony took place to dedicate the Mattingly Planetarium. The new facility replaced the original building destroyed by fire in June 1975.

McDivitt

James A. McDivitt is a native of Chicago, Illinois where he was born on 10 June 1929. His family moved to Michigan and he was educated in the state. Astronaut McDivitt graduated from the Jackson Community College in 1950, and on 20 April 1969, the College honoured him with the naming of the James A. McDivitt Hall of Science. There is also a McDivitt Street in Jackson.

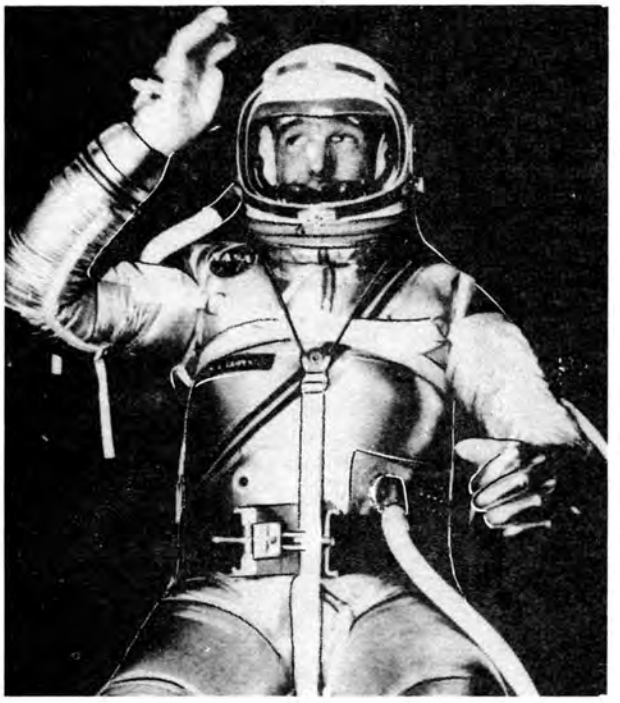
Roosa

Stuart Roosa was born in Durango, Colorado on 15 August 1933. In his honour the town now has Roosa Park and Roosa Avenue (running by the park).

Schirra

Wally Schirra, one of the "Original Seven" Mercury astronauts, was born in Hackensack, New Jersey on 12 March 1923, but he grew up in Oradell a few miles north of Hackensack. After his Mercury flight in 1962, Oradell held home-coming celebrations for him and on 15 October 1962, a one-acre park was dedicated. In the park is a plaque with the inscription: "ORADELL, Home of Commander Walter M. Schirra Jnr. USN. The First Jerseyman To Orbit the Earth Oct 3 1962."

President Carter meets former Mercury astronaut John Glenn during ceremonies to make the 10th anniversary of the first manned lunar landing. At left are the three Apollo 11 astronauts.



Scott Carpenter in a prototype Mercury pressure suit.

Schmitt

Harrison "Jack" Schmitt was born in Santa Rita in New Mexico's Grant County on 3 July 1935. He was a scientist-astronaut and Lunar Module Pilot for the final Apollo mission in 1972. To the west of Santa Rita is Silver City, the principal town of Grant County; here is the Harrison Schmitt Elementary School.

Schweickart

New Jersey is the home state of "Rusty" Schweickart. Although he was born in Neptune on 10 October 1935, he spent much of his early life in Wall township near the Atlantic coast of New Jersey. After his return from Apollo 9 in 1969, Wall High School library purchased a number of science books in his honour and marked each with a bookplate. Also, a roadmarker was erected in the farmlands where he once lived.

See

Civilian Elliot See was born in Dallas, Texas on 23 July 1927. He and Charles A. Bassett II were killed on 28 February 1966, when their T38 jet crashed at the McDonnell Aircraft plant in St. Louis. The 'plane hit the building in which their Gemini 9 craft was being assembled. Astronaut See is remembered at the US Merchant Marine Academy at King Point in New Jersey, from which he graduated in 1949. In the main administration building there is now the Astronaut Elliot M. See Jnr. Room. Dedicated in June 1969, it is the main conference room for the staff of the Commandant of Midshipmen. The See family now live in a housing area at Taylor Lake near the Johnson Space Center in Texas, and in recent years a flag pole complete with flag and a plaque, has been erected at the entrance to the area. Both See and Bassett are interred at the Arlington National Cemetery in Virginia.

Shepard

Al Shepard became the first American in space in 1961 with his sub-orbital flight aboard *Freedom 7*. This historic feat is recognised at the Kennedy Space Center where, in front of the blockhouse at Complex 5/6, is a bronze plaque noting the event. The site was dedicated at a special ceremony on 6 May 1971, ten years after the mission. Alan Shepard hails from New Hampshire where he was born in East Derry on 18 November 1923. Here, a section of Highway 93 is named the Alan B. Shepard Memorial Highway and at the Pinkerton Academy campus is the Alan B. Shepard Auditorium. His achievements are remembered by a number of schools, including the Alan B. Shepard Middle School, San Antonio, Texas; The Freedom 7 Elementary School, Cocoa Beach, Florida, which has a replica of the Mercury capsule at its entrance, and four in Illinois: The A. B. Shepard High at Worth; A. B. Shepard Junior High, Deerfield; Shepard Elementary in Chicago, and the Alan B. Shepard Elementary in Bourbonais.

Stafford

Lt.-Gen. Thomas Patton Stafford, USAF (Retd) is a native of Weatherford, Oklahoma where he was born on 17 September 1930. Weatherford has perpetuated his name by re-titling the street in which he was born as "West Tom Stafford Street" and by placing a commemorative tablet in front of his home. Also, the local municipal airport is Stafford Field.

Weitz

Skylab astronaut Paul Weitz was born on 27 July 1932, in Erie, Pennsylvania. He was raised and educated in the township of Harbor Creek on the outskirts of the City. After his Skylab 2 mission in May 1973, Harbor Creek High School named its football field the Paul J. Weitz Stadium, and all main roads through the town carry markers.

White

A Texan, Ed White was born in San Antonio on 14 November 1930. He became the first American to "walk in space" during the flight of Gemini 4 in June 1965. He was scheduled to be the Command Module Pilot for the first manned Apollo mission, Apollo 1, but he was killed in a fire in the spacecraft in 1967. Ed White was a 1948 graduate of the Western High School, Washington, D.C. In 1967, 250 Western Alumni Association members contributed $2,500 for the Edward H. White Guidance Library at the school. The library owns a colour picture of the astronaut inscribed by him, "To the students of Western High ... Learn your lessons well. The sky is no longer the limit." At Sheppard AFB near Whichita Fall in north Texas a new dormitory was dedicated to him on 13 April 1969. The ceremony was attended by his family, including his father, Maj.-Gen. Edward White USAF (Retd), a former Commander at Sheppard. Seven miles south-east of San Antonio is Brooks AFB, and here a hangar contains the Edward H. White II Memorial Museum. Brooks AFB is the headquarters of the Aerospace Medical Division of Air Force Systems Command and Hangar 9 is now the oldest hangar in the USAF. Funds were raised locally in 1969 to restore the building and it was designated as a National Historic Landmark. On 3 June 1970 the museum was officially dedicated. Exhibits cover the development of manned flight and of aerospace medicine. Also near San Antonio, not far from Randolph AFB, is the Edward H. White Junior High School, dedicated by his wife and son on Veterans' Day, 11 November 1970. Also in Texas, the Edward H. White II Memorial Youth Center at Seabrook near JSC, was a project begun before the astronaut's death. After his success on the Gemini 4 flight, the American Institute of Aeronautics and Astronautics awarded him $500 which he then donated to the Seabrook United Methodist Church, with the hope that one day a centre would be built for the youth of the community. The dream was finally realised after Bob Hope became interested and on 16 May 1970, there was standing-room only in the Houston Astrodome when over 48,000 Bob Hope fans and supporters of the Ed White Mem-

Gemini astronaut Ed White (centre) shakes hands with Yuri Gagarin (far left) at the 1965 Paris Air Show. Next to Gagarin is Vice President Humphrey, while at far right is astronaut McDivitt with French Premier Pompidou standing behind.

NASA

orial Fund attended "The Bob Hope Extra-Special". Mrs. White broke the ground at the site on 7 December 1970 and, finally, the Center was dedicated on 19 September 1971. White was a graduate of the West Point Military Academy and he is buried in a prominent area of the Academy's cemetery. The West Point library has a display case featuring personal items.

Young

John Watts Young was born in San Francisco on 24 September 1930, but he was raised and educated in Orlando, Florida. The Central Florida Museum, opened in 1960, was re-named The John Young Museum and Planetarium. Located in Loch Haven Park, Orlando, it is now a major science museum. The John Young Award, a medal especially struck by the citizens of Orlando, was presented to the astronaut on John Young Day in April 1965. The medal was to be presented to residents of the town in recognition of outstanding achievements. There is also a John Young Parkway in Orlando.

Others

A number of X-15 pilots received astronaut wings as a result of flying the craft to altitudes in excess of 50 miles. One of these is Maj.-Gen. Robert A. Rushworth, USAF, who flew 34 times in the X-15, the individual record. He was born on 9 October 1924 in Madison, Maine and in recognition of his achievements, a wing of the Madison High School was named The Rushworth Gymnasium.

Another group of astronauts was assembled for the ill-fated Manned Orbiting Laboratory (MOL) organised by the Department of Defense in 1963 and then cancelled in 1969. In June 1967, the first black American astronaut became a member of the MOL team. Major Robert H. Lawrence Jnr., USAF was born in Chicago on 2 October 1935 aned died on 8 December 1967 when his F-104 Starfighter crashed at Edwards AFB in California. Sixteen months later, on 25 April 1969, a road near the central offices of the Chicago Housing Authority was named "Major Robert Henry Lawrence Jnr. Lane." Major Lawrence graduated from Bradley University in Peoria, Illinois in 1956, and the University has established a scholarship in his honour awarded to outstanding minority students in the sciences.

A more personal but no less permanent honour has been given to some astronauts with the naming of children. During the Mercury flight of John Glenn happy mothers were inspired to link their newly-born offspring with the mission. It seems to have begun with a child named Orbit Hill in Ogden, Utah. Other names were more specific. These included John Glenn Davis, John Glenn Tinsley, and even John Glenn Apollo. The Apollo programme also helped out with names. Apollo 8 was in the limelight when triplets were born in northern Colombia on Christmas Eve 1968 to the wife of Jose Aguilar. They were named Frank Borman Aguilar, James Lovell Aguilar and William Anders Aguilar. For Apollo 11, a mother in Fife, Scotland, named her son Neil Edwin Michael on 20 July 1969. The tradition continued into 1981. On 14 April at 12:21, two very exciting events were happening to Richard Millsap, Personnel Management Specialist at the Johnson Space Center. His wife Nancy was in Clear Lake Hospital's delivery room preparing to bear their first child when the Shuttle *Columbia* had just completed its first mission. What else could they have named their son but John Robert.

Acknowledgements

The authors consulted the following publications: Astronauts and Cosmonauts Biographical Data (Library of Congress 1981); Astronautics and Aeronautics 1968-1975 (NASA); *Spaceflight*; *NASA Activities*; *Space World*; The Making of an Ex-Astronaut (O'Leary, Joseph 1971); First on the Moon (Apollo 11 crew with Farmer and Hamblin, Joseph, 1970); If The Sun Dies (Fallaci, Collins, 1967); On Course to the Stars (Chrysler & Chaffee Snr, Kregel, 1968); Aviation and Space Museums of America (Allen, ARCO, 1975); *LIFE* magazine. Special thanks are due for encouragement and assistance to: Edward C. Ezell, Historian, JSC, Houston, Texas; Iva Scott, Public Information Specialist, JSC; Curtis Peebles; Lee D. Saegesser, NASA Archivist, Washington, D.C.; David J. Shayler; Marcia S. Smith, Library of Congress, Washington, D.C. and to Public officials in towns and cities across the USA.

REFERENCE

1. *Spaceflight*, 21, April 1979, pp. 147-152.

PARIS IN THE AUTUMN

Dr. L. R. Shepherd (Chairman of the International Liaision Committee) represented the Society at the 33rd IAF Congress in Paris 27 September–30 October 1982. His report and those of other members of the Society attending different sections of the parallel sessions, have been amalgamated below into a report on the Congress.

The 1982 IAF Congress, on the theme "Space in the Year 2000," was held at the Palais des Congrès in Paris. Len Carter was unable to attend due to illness so Les Shepherd was the official BIS delegate – although, of course, there were many BIS members from all over the world present. Altogether, attendance was evaluated as: 850 fully-paid, 130–150 students, and 250 press. The event was well covered by the French media but British press interest was virtually zero.

The host society (AAAF: Association Aéronautique & Astronautique de France) organised the Congress, with honorary patronage of M. Mitterand, the French President, and joint patronage of a number of French ministries and institutions.

Professional secretarial services were provided by a commercial organisation: this is now essential for large conferences without governmental or other large institutional aid at their disposal. Simultaneous with the Congress an exhibition on "Space and Industry" was held in the Palais de Congrès, showing French commercial space interests and dominated by a large model of Ariane. A philatelic exhibition was also held.

Simultaneous translation in three languages (English, French & Russian) was provided for the Opening Ceremony, Forum Sessions and the General Assembly but in two languages (English/French) only at the Technical and Current Event sessions

The technical sessions were arranged in 6–7 parallel streams so that it would have been impossible for anyone to have attended more than 15% of them, particularly taking into account business and committee meetings. They extended from Monday afternoon to the first part of Saturday morning (except Wednesday, a free day). As in all recent Congresses a special feature was the evening Current Event Sessions which were held on Monday, Tuesday and Thursday and featured, respectively, the First French-Soviet Manned Flight, the Space Shuttle and Ariane, and the Salyut-Soyuz Programme. The French and two Soviet cosmonauts presented a commentary to a film of the Franco-Soviet 189-hour orbital flight, assisted in the subsequent discussion by the backup crew who might well carry out a second flight.

Opening Session

This Congress came in the year of the 25th Anniversary of Sputnik 1, and less than 20 years before the year 2000. It was dedicated to defining the requirements for an adequate space capability for the needs of the planet at the turn of the century. Following welcome addresses from the presidents of the AAAF and IAF, an opening speech was made by M. Jean-Pierre Chevenment, the French Minister of State for Research and Technology. He began by noting the progress that had been made in space since the 1st Congress in 1950, and was greatly concerned that it be used only for peaceful purpose. Any attempts to militarise space must be resisted vigorously. Observations from space must be used for the benefit of all mankind and not just certain privileged communities. There must be unambiguous controls over satellites and co-operation between developed and developing countries. It was the duty of the rich countries to educate others in the benefits of observation and other satellites.

Then Dr. Yash Pal, Secretary General to UNISPACE (and head of its Indian delegation), gave the 12th IAF Invited Lecture. He reported on the UNISPACE-82 Conference that had taken place a month before in Vienna. He acknowledged the parts played by the IAF and COSPAR in providing several of the background papers. The Proceedings of the Conference would be published in book form under the title "The World in Space".

The formal report on the Vienna meeting was being finalised. It would be unique among UNO conferences in having achieved a complete concensus. Some of its recommendations dealt with:

1. Studies into the operation of international Earth resources satellites;
2. Substantial programmes for the development of human resources;
3. Stimulation of greater co-operation between countries;
4. Creation of a space information service explaining UN space programme involvement;
5. International efforts to prevent an arms race in outer space.

Dr. Yash Pal said that studies in various countries were being directed towards ensuring that its benefits reach the maximum number of people; disparities must not be further widened. About $3M a year was being provided by voluntary contributions to finance the work. Of this, $2¼M would be used for fellowships and training. Approaches were being made to appropriate States for contributions but countries not able to give money could, perhaps, offer facilities or fellowships.

Dr. Yash Pal emphasised the necessity of space remaining an inviolable environment of peace. His concluding remarks dwelt on the revolution in human knowledge that had already emerged from the coming of the space age and its enormous significance in the further development of mankind.

The remainder of the opening sessions took the form of a Forum chaired by J. Gruau of CNES. The speakers were H. Curien of CNES, E. Quistgaard, Director General of ESA, A. Kotelnikov of the Intercosmos Council of the USSR Academy of Science and I. Bekey of NASA. The theme of their talks concerned the forthcoming programmes of their respective organisations up to the end of the century. Bekey, who spoke at some length, emphasised the importance which NASA set upon

The UNISPAC conference was held in Vienna.

Alan Lawrie.

space transportation systems which formed the infrastructure for all future space activities.

Social Occasions

A complete programme of social events was organised. Every evening saw a reception or optional visit somewhere. These started on Sunday 26 September at 6 p.m. with a welcoming cocktail party hosted by ŞPER (Syndicat des Industries de Matériel Professionel Electronique et Radioélectrique).

A lavish reception for all participants took place on Monday evening, sponsored by the French aeronautic and space industries (GIFAS). On Tuesday evening there was a reception at the Hotel de Ville given by the Mayor of Paris for a limited number of guests, including the Delegates from all the IAF Societies, and an Organ Recital in the famous Eglise de la Madelaine. On Wednesday morning and afternoon visits were arranged to the historic Chateaux of Fontainebleau and Vauxle-Vicomte or, alternatively, field trips to French national and industrial space centres and ESA Headquarters. Paris contains the hub of several major French space organisations, notably ONERA and CNES.

On Thursday a visit to the ballet at the Théâtre des Champs-Elysées was arranged but the crowning event of the social programme was undoubtedly the Gala Dinner at the Chateau de Versailles, without doubt one of the most spectacular banquets in the history of the Congresses.

Although the Congress proper was closed at noon on Saturday 2 October further excursions were organised to Champagne vineyards and Rheims Cathedral. There were also post-Congress tours to a number of localities lasting right through until Tuesday 5th October.

The Accompanying Person's Programme was the successor to what the previous year had been called the "Ladies Programme". It still showed a definite female bias however, including a presentation of Pierre Cardin haute couture and coach trips to chateaux and art centres. It was rounded off on the Saturday with a visit to the Flea Market.

Business Sessions

The General Assembly met on Monday (27th September) and Friday (1 October) afternoons. Twenty-eight of the 60 voting members were present, as were 15 others (members, institution members and associated members). Five observers were admitted from international organisations *viz* UN, COSPAR, WHO, WMO and ITU.

The membership of the Astronautical Society of Australia was terminated, as contact had been lost with it! A new body (the Foundation for Space Activities and Studies of Brazil) was admitted. An organisation called the Sociedad Interplanetaria Brazileira (SIB) had also applied for voting membership (the other Brazilian newcomer became only an institutional member; only one voting member per country is admitted) but a decision was postponed pending more information. The English translation of the name incidentally (Brazilian Interplanetary Society) means another BIS could join the fold!

Decisions were taken on fees for membership, which would be rationalised to units of $150, and for registrations fees for the next Congress. It was decided that IAF finances, in future, should be in Swiss Francs, another rationalisation. (Dr. Gibson pointed out that the IAF was rich in Polish currency but could not touch it, so there was general agreement fees should be in convertable currency in future).

The Swedes withdrew their invitation to hold the 1984 Congress in Stockholm, so the Bureau decided to solicit other institutions. The (Brazilian) BIS had already made an offer but since they were not yet members this could not, at this stage, be accepted. Israel, too, also offered to host the meeting, in Haifa.

A great deal of groundwork over the year had been done in IAF circles on the idea of holding Congresses once every two years instead of annually. As a preliminary to this the idea had been put forward to make the administrative meetings biennial to free Congress

time for technical and scientific papers. This would require some amendments to the constitution. In the event, consensus was not reached so a decision on the constitutional changes was deferred, as was the decision on the future frequency of Congresses. Other amendments to the Constitution were passed, including the proviso that decisions would be taken by consensus in future (as discussed at the 1981 Congress, see the February 1982 *Spaceflight*, p.60), and some liberalisation of the requirements for membership. Proposals that a third of each year's officers should be elected from candidates not previously officers, and that the President must have previous experience as an elected officer, were defeated.

Committee and working group reports were taken on Friday, when Les Shepherd was elected Vice Chairman of the Space Energy and Power Committee. An investigation of the Committee structure was underway to see if it could be rationalied.

On international relations, it was reported that co-sponsorship by IAF and COSPAR (Committee on Space Research) of a joint forum at UNISPACE had been such a success that regular contact would now be maintained.

Dr. Juliane, on behalf of the UN, thanked IAF, IAA and IISL (see below) for their support at UNISPACE '82. It was also decided that the IAF would accept an invitation from the IAU (International Astronomical Union) to apply for affiliate membership. This would give the IAF suitable sponsorship should it need to be represented at the ICSU (International Council of Scientific Unions) meetings.

Two bodies set up by the IAF are the IAA (International Academy of Astronautics) and the IISL (International Institute of Space Law). At the IAA special meeting on Tuesday (28th September) a new president was elected. Dr. Stark Draper (a Fellow of the Society) was retiring after 19 years. Dr. George Mueller (another Fellow and ex-Associate Administrator of NASA, in charge of manned space flight from Gemini to Apollo) was chosen as his successor. Dr. Mueller joins a distinguished list of Presidents; before Dr. Draper it had been Frank Malina and Dr. Theodore von Karman.

New Officers

New officers for the IAF were approved as follows

President	:	Dr. R. Chevalier (France)
Members	:	Prof. I. Almar (Hungary)
	:	Herr W. Bueddeler (West Germany)
	:	Dr. J. Grey (USA)
	:	Dr. D. Mori (Japan)
	:	Dr. Rychlewski (Poland)

Dr. L. Perek automatically held office as Past President.

1983 Congress

The next Congress will be held in Budapest Hungary (home of Theodore von Karman) on 9–15 October 1983. Its theme will be "Cooperation in Space". Most of the Symposium subjects from 1981 and 1982 would be carried over to this next Congress. The host-society would be the Magyar Astronautikai Egyesület. Papers were now being solicited. Entries will be welcomed even from IAF non-members.

AN OVERVIEW

Most seasoned conference-goers notice one major change from their normal round when visiting the IAF Congress. Whereas one meets the same faces at the specialist conferences, to the point where one wonders who in a particular discipline is actually staying at home and *working*, there is, at the IAF Congress, the air of a reunion of family members, all of whom are taking the chance of this annual get-together to renew acquaintances. Certainly there was much coming and going between groups at the early cocktail parties, with the occasional newcomers looking rather forlorn and lost.

The plenary sessions, intended to lead us to the theme of Space 2000 did, in fact, take us on a more immediate and more important task: the need for co-operation. There was an underlying threat, voiced directly only by Professor Yash Pal, but always lurking in the background that, if there was not co-operation because nations could not be persuaded to pursue the peaceful use of space, then we were about to embark on a space arms race.

The theme of co-operation ran through the Current Events which attracted the biggest gatherings of delegates; co-operation on the first Franco-Soviet manned space flight, co-operation on the Ariane programme, co-operation over the Shuttle-Spacelab flights, co-operation in Earth Observation. The "amateurs", not to be outdone, vowed co-operation for a solar-sail race to the Moon.

The only persons who could be forgiven for doubting such sentiments were the many speakers who, having spent hours (if not days) writing their speeches, found themselves with minimal audiences. Your reporter, making one round of the lecture rooms, decided that more than 70 per cent of the conference members were elsewhere in Paris!

Remembering the amount of effort put in by the organisers one wonders whether an annual congress on these lines is really justified in these days of high costs. This is especially so when it is recognised that, each year, a different organising committee is set up which has, more or less, to re-invent the wheel, as it becomes almost a matter of national pride to "go it alone." Even so august a body as COSPAR decided that a conference every two years is all that can be afforded.

Of course, there are those who believe in the Congress for other than social purposes. Jerry Grey, in an interview for the Congress newspaper "The Gazette", pointed out that here was a unique opportunity for meetings between scientists and technologists from both sides of the iron curtain on an informal basis.

Two final impressions; one bad, one good. The view down a long room filled with piles of papers (200 of each produced and carried by the speakers) being SOLD for $3 – each irrespective of length or subject. As the speakers had themselves had to pay for the privilege of speaking to near-empty rooms in some cases, as well as providing free copies of the papers, one can well understand the almost universal condemnation of the system amongst Congress members.

And the good impression: a superb phrase from Professor Yash Pal which should go down in the annals of space literature – "Space is as democratic as sunlight."

Of course there is another side to the coin. It should be remembered that the IAF relies on the Congress for a major part of its income. Without that income a great burden would fall on member-societies. One recognises a familiar pattern exacerbated, in this case, by many potential participants having to choose most carefully on which conferences they spend a dwindling amount of money.

NORMAN LONGDON

NEXT MONTH we will publish reports on some of the individual sessions held in Paris.

THE 37TH ANNUAL GENERAL MEETING

In the Chair: Mr. A. T. Lawton, *President*

In attendance: *Members of the Council*, Mr. M. Fry, Mr. G. V. E. Thompson, Prof. G. V. Groves, Mr. G. Webb, Dr. A. R. Martin; and about 30 members.

Presidential Address

The President welcomed all present and explained that the business of the Annual General Meeting, once again, was to receive the Council's Annual Report on Society activities, this time to 31 December 1981, together with its Financial Statement for that year. A printed report indicating the main points had already appeared in *Spaceflight*. These matters would now be reviewed once more and, where appropriate, Committee Chairmen be invited to provide additional information.

The President then summarised the main points in the printed Report, his main theme being the forthcoming events of Space '82 and the Society's 50th Anniversary.

On the matter of International Relations, particularly, our Society was now playing an increasingly important role. Our views and opinions had been much sought after and held in high esteem. The Society, in turn, was greatly appreciative of this measure of confidence. He emphasised the strong support given by the Society to the IAF. This did not only refer to technical matters but also to financial ones. The Society was one of the main financial contributors to the IAF and was, of course, one of the founders of that organisation.

The President also pointed out that the hope expressed in the Report that *Space Education* would be accepted as a publication in its own right was now a fact.

Daedalus has now gone into second print and our new book, "The Eagle Has Wings", referred to in the Report as our next major fund-raising activity, has now been published. It is a very good book indeed, excellent value for money, and we hope that it will prove very popular.

The President stated that Membership had remained static during a depressed period but we were always on the alert for new members who would be made welcome. Our Society always attempts to reach and involve a wider public. We need publicity from and by our members to achieve this. Our measure of success has appeared in several reports about activities of this nature which have appeared recently in *Spaceflight*.

The President amplified the tasks and functions of the Library Committee. The task was becoming increasingly difficult because rare books were now difficult to obtain but, so far, we had been extremely fortunate.

He wished to take this opportunity of sincerely thanking those members and others who had kindly donated books, original reports and other related documents to help the Society in this very worthy task.

At this point Mr. M. R. Fry, Chairman of the Space '82 Committee, was invited to provide an update on the Brighton arrangements. Mr. Fry responded by saying that the Space '82 programme was currently being prepared and it was hoped that this would draw a good attendance. It was the first event of this nature to be held by the Society.

The President continued by pointing out that Space '82 was an initial venture to celebrate the Society reaching its 50th Anniversary year. This would start on 14 October 1982. The actual Anniversary would be reached on 13 October 1983. Fifty years was indeed a long time. Very few space societies had lasted that long under their own flag!

Balance Sheet and Accounts

The Executive Secretary reported on the Balance Sheet and Accounts for the year to 31 December 1981. The most important fact was that these placed the Society within striking distance of paying off the final indebtedness on its new premises. The whole project of developing, setting up, equipping and staffing a completely new HQ was a major activity which the Society, through its members, had undertaken solely on its own. For this reason alone each member of the Society should feel considerable satisfaction that such a major task had been accomplished so well and so quickly.

Our new HQ was attracting members of the Society from all over the world, all of whom had expressed themselves most favourably and, in many cases, had been moved to provide further help to enable the work to be completed!

Many had expressed surprise at the new building which had arisen on the former vacant site next door. The front of the building erected there was identical in appearance to the Society's facade. This had prompted some members to wonder if we had recently expanded our building considerably! Unfortunately, this was not so. The adjacent land, in which the Society had been very interested, had been sold at a greatly enhanced price, much more than the Society could afford. However, planning permission had been given with the stipulation that the building erected should match the Society's HQ in every material respect, hence the nice-looking result but unfortunate effect that the Society's offices had not expanded in the manner once hoped for!

The Executive Secretary explained that the repayment targets achieved had been remarkable. Some seemingly impossible tasks had been done and extremely difficult targets met. The President pointed out that the Society had achieved all this without any additional aid in the form of Government grants or other financial assistance. We had done this *ourselves* and, without being patronising, could afford to congratulate ourselves on a most successful achievement.

On the proposal of Mr. G. V. E. Thompson (Fellow) seconded by Mr. P. Girton (Fellow), the Accounts were approved unanimously.

Appointment of Auditors

The President reported that our existing auditors, Fraser Keen, had offered themselves for re-election. On the proposal of Mr. T. J. Grant (Fellow) seconded by Mr. G. Phillips (Fellow) the re-election of the auditors at a remuneration to be agreed upon by the Council was unanimously approved.

Council Elections

The President then stated that, in accordance with the Society's Articles, four members of the Council were due to retire. Of these, two (Dr. L. R. Shepherd and Mr. G. M. Webb) had offered themselves for re-election. Mr. P. J. Conchie and Mr. K. W. Gatland were not standing for re-election. Both had done a great deal of good work for the Society. For this reason he proposed that the meeting record a vote of thanks and wish them well in the future.

This was agreed unanimously.

Five candidates had offered themselves for re-election i.e. Mr. G. W. Childs, Mr. T. J. Grant, Dr. L. R. Shepherd, Mr. F. R. Smith and Mr. G. M. Webb.

Since the number of candidates exceeded the number of vacancies, election would be carried out by postal ballot in the usual manner, with 31 January 1983 adopted as the final date for the return of the ballot papers.

General Discussion

Mr. F. R. Smith (Fellow) asked if further information could be provided regarding donations received by the Society.

The Executive Secretary responded that the total receipts from all sources i.e. Deeds of Covenant, donations, saleable profits and special donations all appeared as the last line under the heading "Contributions received to date" under Note 2 attached to the Society's Accounts and headed "Fixed Assets". This showed both the total receipts and

how these had been utilised to the end of each calendar year.

In regard to individual activities, Deeds of Covenant last year produced about £1,500 p.a. as had been announced several times in Society magazines. For 1982 we were hoping to receive £1,700. He urged members liable to UK Income Tax to support this activity, particularly as it could be done with little or no effort by Members.

General donations from individual members were tending to fall off though several sizeable Special Donations had been received. Details of some of these e.g. for Library purposes, had been mentioned in Library Reports. This was a practice which would be continued. Much of our income to cover the indebtedness of the property, etc., however, had stemmed from special fund-raising projects undertaken by the Society, the latest being "The Eagle Has Wings", as the President had announced earlier.

It was hoped that this would prove as successful as Project Daedalus, which had proved particularly valuable and had assisted the Society materially at a crucial time. Every member who bought copies of the Society's three books ("Project Daedalus", "High Road to the Moon" and "The Eagle Has Wings") was helping directly in its work. The books, themselves, were extremely reasonable in price.

The President said that "The Eagle Has Wings" was one of the most detailed histories of what happened and how it happened in the American space programme. Mr. A. Wilson had done a remarkable job in preparing this, as had other members of the staff who had shouldered much of the production work. The cost was only £7, post free, which was amazing value for a 144pp publication. It bore a proud title and was a book that was about the "guts and go" of a space programme, containing details of many episodes not generally known to the public.

Mr. Thompson pointed out that the Accounts were in a format demanded by law and as recommended by our Auditors.

Mr. G. M. Webb drew attention to the continuing increase in the costs of publications, and mentioned that these were just about balanced by the income received from subscriptions.

The President said that, in spite of the recession, there was a continuing upward pressure, not only in printing rates, but also in paper and postage charges. It would be a naïve assumption to assume that our subscription rates would ease off immediately, in spite of our best endeavours to do so, for the Society is always two or three years behind in charging the rates to meet its actual costs! The problems of inflation are always with us even if currently 6 per cent, for the backlog may still be inflating at twice that rate.

The Executive Secretary said that one incidental income stemming from publications was the fact that a Russian edition of *Spaceflight* had been appearing, apparently since 1946. Since the Soviet Union had subsequently signed the Copyright Convention, agreement for publication in the USSR and similar countries had been reached whereby the Society received an annual Royalty on sales.

Mr. C. M. Hempsell asked if there was any possibility that "The Eagle has Wings" might be selected as a Book Club selection. The Executive Secretary thought this would be nice *if* it could be arranged, for it would generate considerable publicity and substantial revenue for the Society as well. The fact of the matter was, however, that our book had to compete with large numbers of commercially-produced books which, understandably, tended to be accepted in preference, perhaps because the business arrangements in such cases were easier to make.

Mr. F. R. Smith said he was concerned about a Council Bye-Law which said that the Council would indicate, on the ballot paper, those candidates which, in its view, seemed best able to undertake the work of the Society. He thought this implied that the Council wished to guide members in exercising their voting rights.

Professor Groves responded that, by the same token, the converse could equally be true. Members could also see who to vote against! In fact, the new Bye-Law had been framed in response to requests from members over many years seeking further guidance on the actual capabilities or suitability of candidates to carry out Council tasks. The practice mentioned was one now adopted by many other organisations and found to work well.

The Council and the Society's solicitors had considered the change very seriously and had come unanimously to the view that this was a very desirable way of meeting the wishes of members to enable them to exercise their votes in the light of all the relevant data presented to them.

Mr. F. R. Smith then argued that each Council candidate should be allowed to make a personal statement.

The President replied that this was completely contrary to the practice of the overwhelming majority of Learned Societies. The Council intended to see that our own Society reached the highest professional levels. This required that we be seen to act accordingly.

Mr. G. V. E. Thompson said that "personal statements" were more appropriate to political elections. It smacked of a political manifesto. Our Society should not venture down this path. It had no interest in setting up rival parties. Members were entitled to assume that all candidates came forward for the same purposes and that there was no difference between them in their objectives.

Professor Groves said that members were very much more concerned with receiving information on what would be best *for the Society*, and not just simply in a tract publicising why someone felt *he* should be a Council Member.

Mr. G. M. Webb commented that, in reflecting on all the societies to which he belonged, there were none in which elections based on personal statements took place. Reading the new Bye-Laws of the Council demonstrated beyond any doubt at all that the Society had now been made much more strongly democratic, not less so. There was a danger in allowing long personal manifestos, which often clouded essential information.

A further comment from the floor criticised the Manifesto argument by pointing out that political parties who issued such documents often disclosed a great gap between what they *said* and what they *did*. The two were often very different things!

The President pointed out that the great majority of people who appeared on ballot lists and were voted on to the Council were already known to Members. They were not necessarily known by personal contact but by what they wrote in contributions to Society publications and what they did for the Society. They were known by deeds, not words. It was this that formed the major influence when voting for candidates.

Mr. M. Irvine pointed out that the Society's influence had penetrated into several new areas, e.g. Project Daedalus had been requested in terms of film footage from the BBC programme "Spaceships of the Mind."

Dr. A. R. Martin added that a request for footage had been made by Granada TV and it was being shown on 27 October 1982 as part of the new network series "The Final Frontier".

Mr. Thompson said that he would like to record a personal vote of thanks for all the work done during the year by the Society's Office Staff. He would especially commend the Executive Secretary who, although this was not generally known, had been extremely ill in the week preceding the AGM.

This was echoed by the President who pointed out that it would not have been possible to postpone the AGM so the Council had drawn up contingency plans. Fortunately, they weren't needed. On that happy note the Meeting was concluded.

BOOK NOTICES

Satellites of Jupiter
Ed. D. Morrison, University of Arizona Press, 972 pp, 1983, $49.50.

One of the most exciting discoveries of recent years stems from the Voyager 1 and 2 pictures of the satellites of Jupiter. Before the Voyager discoveries in March and July 1979, a book like this could hardly have been conceived. Practically the whole of its content is based on data from these two spacecraft encounters which presently makes it the only book around which deals with the Jovian satellites both as individual worlds and as a system.

More than half of the volume is devoted to the volcanic activity recorded on Io, observations which must rank as one of the most significant discoveries ever. Just before the encounter, an analysis of tidal heating had predicted that the interior of Io would be molten and that surface activity was probable. During approach, the absence of impact craters seemed to support this prediction but the later direct observation of eight active volcanic plumes erupting to altitudes as high as 300 km, and the detection of hot spots and a possibly transient sulphur dioxide atmosphere, clearly put Io in a class by itself.

Voyager observations of the other Jovian satellites were also highly productive. Europa appears to have a relatively smooth ice surface and a remarkable geology dominated by tectonic effects. Ganymede and Callisto both have crusts strong enough to preserve a cratering record. In fact, Ganymede's geology shows evidence of tectonic activity but, in surprising contrast, Callisto, its near-twin, shows no such evidence of internal geologic activity.

The Galilean satellites have now been revealed as individuals with much greater diversity than expected and, therefore, of correspondingly much greater interest as examples of planetary evolution.

The book is based on contributions by no less than 40 planetary scientists. With its 165 line drawings, 180 photographs and appendices on cartography and nomenclature for the Galilean satellites, it is one of the most exciting books on astronomy to appear in recent times.

Spacelab, Space Platforms and the Future
Eds. P. M. Bainum and D. E. Koelle, AAS, 502 pp, 1982, Hard Cover $55.00, Soft Cover $45.00

This volume contains the Proceedings of the Fourth AAS/DGLR Symposium and the Twentieth Goddard Memorial Symposium, held early in 1982. These joint meetings have been held alternately every second year in Germany and the USA since the first meeting in 1976.

The object was to provide a forum which would suggest requirements for the next generation of civil space missions, concentrating on the exploitation of space, both present and projected, for the benefit of mankind.

The sessions were on Spacelab Mission Plans, Space Platforms and Stations, Space Science Missions, Earth-Orientated Activities and Space Transportation, and an Annual History Program was also included.

The session on Spacelab Mission Plans ran to seven papers while Space Platforms produced four. A further major session was on, basically, Remote Sensing, which produced nine papers. The session on Space Transportation Systems, though only embracing three papers, is particularly interesting for it postulates future development of the Shuttle and European launch systems, respectively, as well as provides guidelines on many aspects of the costs of launch vehicle development.

Science Fiction and Space Futures: Past and Present
Ed. E. M. Emme, AAS, 278pp, 1982, $35 (Paperback $25).

The papers in this volume span fictional space futures from Lucien, in the First Century A.D., more or less up to the present day, with some philosophy thrown in for good measure.

The fictional side is not too profound. There are only two contributions in this category, one a relatively general review but the other a heavyweight blow-by-blow account by Fred Ordway of his involvement with the making of the film "2001". Other contributions relate to space art, the impact of science fiction on attitudes towards technology and a comparison between science fiction and science fact.

Philosophical attitudes emerge more clearly in later papers e.g. concerning such topics as religions for a galactic civilisation. Plenty of discussion is reported and quoted verbatim but there is no doubt that most readers will turn straight to the "2001" contribution, which is very well illustrated, and tend to orbit around that for quite some time.

Global Implications of Space Activities
Eds. J. Grey and L. Levy, AIAA, 151pp, 1982, $18.50.

This volume is based on a Conference whose intent was "to bring humanists and technical people together in open discussion . . . to highlight the key elements in the relationship of space technology to human needs." Topics of specific interest were the role of space in communications, the Earth's environment, management of resources, international cooperation, and other challenges facing mankind in achieving a peaceful and stable world.

The book features in-depth essays on the global implications of space, space science, communications, and Earth resources, each followed by Workshop reports concerned with evaluating some of the major issues raised e.g. national *v.* international trends, the needs of developed *v.* those of emerging countries and manned *v.* unmanned programmes.

Mysterium Cosmographicum (The Secret of the Universe)
J. Kepler (trans. A. M. Duncan), Abaris Books, pp, 1981, $20.00.

Although Johannes Kepler is universally esteemed as one of the major scientists of the seventeenth century and one of the greatest astronomers of all time, his reputation has not been paralleled by a series of translations of his works into any languages other than German. In fact, until now, not one of his major publications, in which his discoveries were disclosed, has appeared in a complete English version.

The current volume is an annotated translation of Kepler's first full-dress essay in astronomy. The original, published in 1596, marked his public appearance as a major astronomer. The current volume usually appears in the literature of the history of astronomy primarily because it contains the first astronomical "law" that Kepler discovered, i.e. the geometric relation between the average distances of the planets from the Sun.

The translated volume consists of a reproduction of Kepler's original text in Latin, on the left hand side of each page, with the translated version on the right, together with author's notes on each chapter. It is to be hoped that this book will pave the way for the translation of some of Kepler's later works. English readers have waited for them long enough!

The Physics of Stars
S. A. Kaplan, Wiley, 158 pp, 1982, £15.75.

This book provides the student and amateur astronomer with an insight into the physics of stars, demonstrating the study of their structure and the processes taking place within. It enables the reader to calculate the characteristic parameters of stars, such as their temperatures, by using simple physics. He can then progress to study more complex problems such as stellar evolution and the sources of stellar energy.

The author has simplified the necessary mathematics by using formulae which should be familiar from school physics, or by giving thorough explanations of any new ones.

The Milky Way; The Structure and Development of our Star System
L. Kühn, John Wiley & Sons, 151 pp, 1982, £14.25.

This book presents a modern view of the Milky Way system and its individual elements, based upon observations.

Our Galaxy, also called the Milky Way, has become a focal point for astronomical research. Radio astronomy has defined its spiral structure over a wide range, while parts, invisible until fairly recently, can now be picked up in the infrared. The advent of fast computers has meant that the movements of thousands of stars and of the interstellar gas can be plotted, thus accelerating research into the dynamics of this most complicated system.

The author begins by discussing individual stars and groups of stars and then proceeds to form, into an coherent picture, the essential components of the system i.e. star clusters, dust clouds and gas.

Both the development of the structure and the dynamics of the system are then examined, with emphasis on the physical characteristics.

STTI'S International Satellite Television Reception Guidebook
S. J. Birkill, Satellite Television Technology International, 78pp, 1982, $40.00.

This book attempts to fill the gap which exists between the US home terminal industry and the rest of the world where satellite systems operate in totally different formats.

Practical details are given for those who wish to build receivers or adapt existing equipment for compatibility with international standards. Readers will discover how to cope with circular polarization, PAL, SECAM and NTSC, independent audio carriers, companding systems, half-transponder video and non-geostationary satellites, among others.

Current topics dealt with include a list of geosynchronous satellites, transponder frequencies, video standards, colour systems, etc.

Not only does this volume set out to help determine what size antenna one will need, it goes on to provide a guidebook to setting up a TVRO Terminal almost anywhere in the world.

The Gustafson's Spherical TVRO Antenna Manual
M. L. Gustafson, Satellite TV Technology, 68 pp., 1982, $30.00.

The concept behind the spherical antenna for receiving TV satellite pictures described in this volume was that it had to be easy to build yet not require any knowledge of mathematics nor cost too much. In fact, the target cost was something less than $300.

The requirement was for a 12-ft antenna built mainly of wood covered by a screen mesh surface and supported by a suitable stand, which could be built with the use of only the most basic hand tools and still provide excellent pictures. The author indicates that the particular antenna described could be constructed by an average handyman in around 40 hours. He adds that construction is not difficult, merely tedious.

Inside Modern Technology; How It Works
Sidgwick & Jackson, 185pp, 1982, £9.95.

A wide-ranging illustrated colour book of particular interest to those with a technological bent who wonder how many of today's technical marvels are achieved. Good space section with clear diagrams and easy-to-read explanations.

Astrophysical Parameters for Globular Clusters
Ed. A. G. Davis Philip and D. S. Hayes, L. Davis Press, 614pp, 1981, $25.

Much activity has taken place in the field of globular cluster research of late. Work on clusters in the Magellanic Clouds, particularly, has been very active. Theoreticians, too, have been improving their models. For this reason, the IAU held a colloquium on the subject at which 83 papers were presented. The proceedings of the colloquium have now been published, edited from camera-ready copy submitted by authors.

The proceedings are divided into nine main sections. The first is on UV and X-ray observations, the second on cluster abundancies, which appear to present considerable difficulty, and a third on cluster dynamics. The Magellanic Clouds rank next, with a major section on their own, representing enhanced interest in these extra-Galactic neighbours, a process extending further afield after two chapters on theory, with searches for globular clusters in nearby galaxies e.g. M31, M33, etc. This includes important but controversial evidence of fundamentally important differences which appear to exist between the globular clusters in M31 and those in our own Galaxy. Clearly, this is a problem which will rank a high priority with the more powerful instruments now becoming available.

After consideration of the age of globular clusters the volume ends with a section on photometry.

NASA Astronaut Biographical Data Record Book
D. J. Shayler, Astro Info Service, 104pp, 1982, £3.50 (soft cover).

This is a privately-produced booklet reproduced directly from a typed original, covering the careers of the NASA Group 3 astronauts selected in 1963.

The Bright Star Catalogue
D. Hoffleit, Yale University Observatory, 472pp, 1982 $35.00.

The Catalogue is grouped into three main parts. It begins with an introduction explaining the data provided, followed by the Catalogue proper. The remainder is taken up by Appendices and supplementary remarks which contain further information about some of the stars but also detail some 200 stars not included in the Catalogue.

Some of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

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PROJECT DAEDALUS

JOURNEY TO THE STARS

The publication of the Project Daedalus Final Report marked the end of years of painstaking work by a group of BIS pioneers. The BIS received congratulations from around the world for its far-sighted project: designing a probe using reasonable technology for man's first crossing of interstellar space.

The Final Report contains 24 papers spread over 192 large-format (A4) pages, summarising the four year study. The papers cover the overall spacecraft design, mission profile, computer systems, navigation, experiments and our knowledge of nearby stellar systems, some of them possibly with planets.

"Daedalus" is acknowledged as a milestone in the development of advanced astronautics. Copies of the Report cost just £7.00 ($16.00) post free, from The Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ, England.

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

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NOTICES OF MEETINGS

Lecture

Title: **SPACE OCEANOGRAPHY**
by Dr. J. O. Thomas
Imperial College, London

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **16 March 1983,** 7.00–9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Study Course

Title: **CATACLYSMIC VARIABLES**
by Dr. D. Jones
Royal Greenwich Observatory

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **30 March 1983,** 7.00–9.00 p.m.

Registration forms for the Study Course are available from the Executive Secretary. Please enclose a stamped addressed envelope.

Study Course

Title: **THE INTERSTELLAR MEDIUM**
by Dr. M. Pettini
Royal Greenwich Observatory

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **6 April 1983**, 7.00–9.00 p.m.

Registration forms for the Study Course are available from the Executive Secretary. Please enclose a stamped addressed envelope.

Study Course Visit (Open to non-Course Members)

The final meeting in the Astronomical Study Course is an accompanied visit to the Royal Greenwich Observatory at Herstmonceux on **14 April 1983.** Arrival will be at 1.30 p.m. The tour will begin at 2.00 p.m. and last for about two and a half hours, followed by admission to a special exhibition. Arrival by train is not recommended as the nearest station is about five miles away. Further information is available from the Executive Secretary. (Please enclose a stamped addressed envelope).

Technical Forum

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **Friday, 3 June 1983**, 6.30–9.00 p.m., and **Saturday, 4 June 1983**, 10.00 a.m. to 12 noon and 1.30–3.30 p.m.

Topic: **THE SOVIET SPACE PROGRAMME**

It is anticipated that papers will be given at the Friday evening and Saturday afternoon sessions, with some Soviet space films being shown during the Saturday morning session.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society. Members with a special interest in the Soviet space programme are invited to attend. A registration fee of £3.00 is payable. Forms are available from the Executive Secretary on request, enclosing a stamped addressed envelope.

18th European Space Symposium

Theme: **FUTURE SPACE PROGRAMMES FOR EUROPE**

To be held in the Society's Conference Room at 27/29 South Lambeth Road, London, SW8 1SZ on **8–10 June 1983.** Organised by the BIS and co-sponsored by the DGLR, AAAS, AIDAA and AAS, with support from Eurospace. The number of participants will be limited to a maximum of 60, with priority to Speakers, Society Representatives and subject specialists.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society.

Programmes and Registration forms will be available in due course.

34th IAF Congress

The 34th Congress of the International Astronautical Federation will be held in Budapest, Hungary on **9–15 October 1983.**

Theme: **COOPERATION IN SPACE**

Members of the Society wishing to present papers are asked to notify Dr. L. R. Shepherd, Chairman of the BIS International Liason Committee at Society HQ as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

LIBRARY

We are seeking many technical books on astronomy, space research and space technology, and would welcome hearing from members with material they would like to donate to us to help fill the gaps.

The Library will be open to members from 5.30–7.00 p.m. on each of the following dates:

16 Mar. 1983 30 Mar. 1983
6 Apr. 1983

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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SPACEFLIGHT

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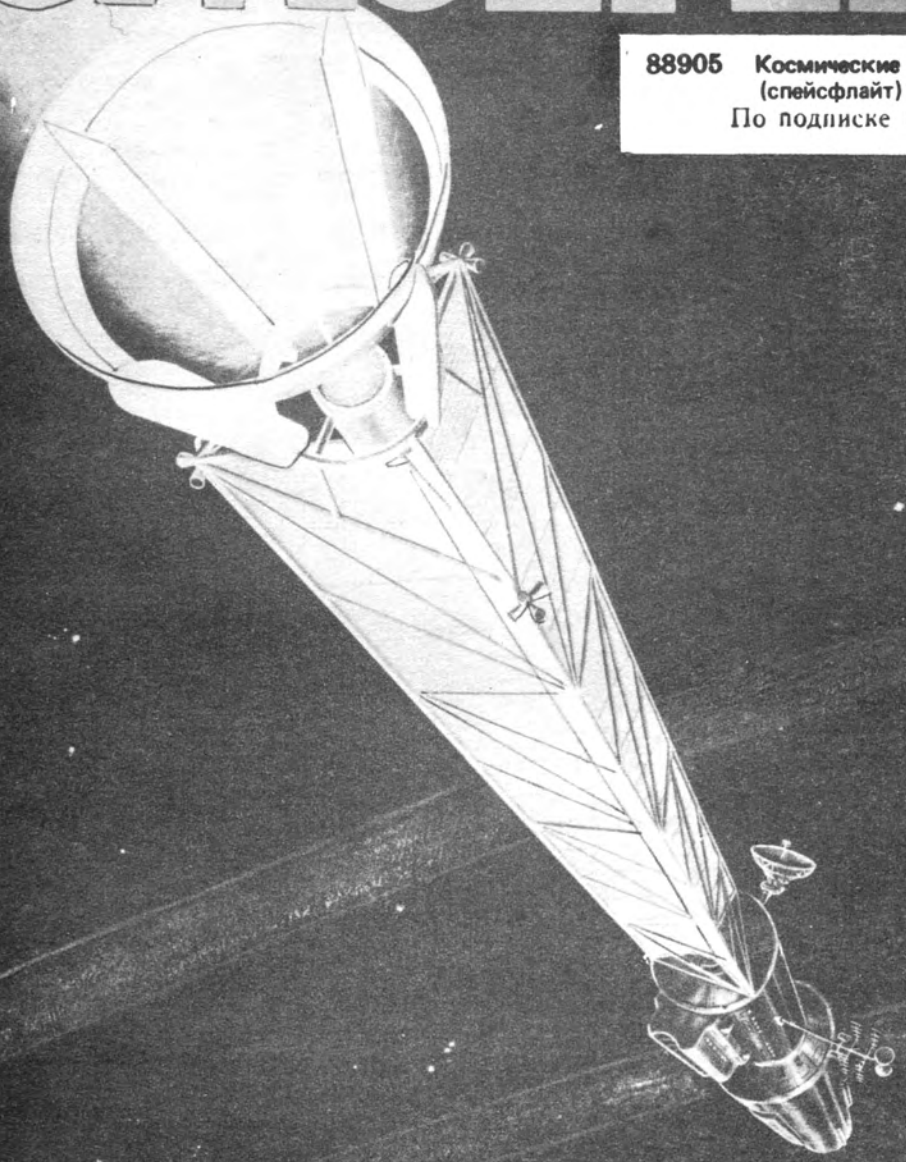

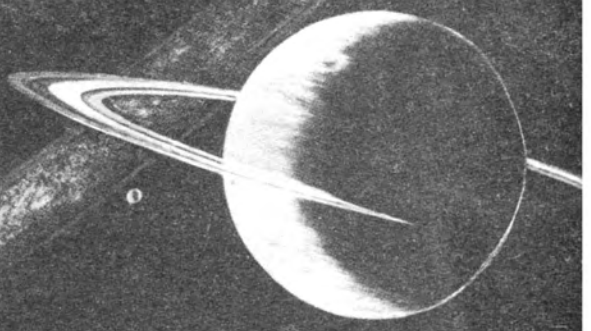

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SPACE PROGRAMMES FOR EUROPE

18TH EUROPEAN SPACE SYMPOSIUM

Venue: The British Interplanetary Society, 27/29 South Lambeth Road, SW8 1SZ, England

Dates: *8–9 June 1983* (All Day).

Offers of papers are invited. Contributions of 10 minute technical presentations to provide updates on current work will also be of interest.

Papers already accepted for presentation include:

1. Dr. A. G. Adelman	Precision Laser Satellite Tracking for Global Tectonics
2. D. M. Ashford	Low Cost Transportation to Orbit – The Kev to the Universe
3. M. Bergman	Solar Sailing
4. R. A. Buckland	Insurance and Commercial Activity in Space
5. Dr. G. Greger	The Potential of Manned Space Technology for Future European Application
6. Dr. H. Kappler	Evolutionary Concepts for Space Stations and the Relevant Utilisation Potential
7. Dr. D. E. Koelle	Dedicated Reusable Space Platforms – A New Economic Tool for Space Research and Application
8. G. Rausch	Remote Sensing Missions of the Future Decade
9. Dr. R. Parkinson	Towards the Million Dollar Launcher

Language Presentation: All Lectures will be delivered in English.

Sponsored by: Deutsche Gesellschaft für Luft-und Raumfahrt, Associazione Italiana di Aeronautica E Astronautica, The British Interplanetary Society, American Astronautical Society, with support from Eurospace.

Final Programme: Copies will be available nearer the date of the meeting. Late modifications to the Programme will be announced as information is received.

Further Information: Apply to the Executive Secretary the British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ. Telephone: 01 735 3160.

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SPACEFLIGHT

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CONTENTS

178 **New Opportunities for Man** *Erik Quistgaard*

187 **Test Your Space Knowledge**

188 **News from the Cape** *Gordon L. Harris*

190 **Space Report**

193 **Japan: First with DBS** *Neil W. Davis*

195 **Small is Beautiful**

196 **Seeing is Believing**

200 **Shuttle Resumé**

202 **Antimatter & Distant Space Flight** *Dr. George Mueller*

211 **Personal Profile** *Dr. William McLaughlin*

215 **Paris in the Autumn (Part 2)**

219 **John Young: One Man's Conquest of Space (Part 3)** *David J. Shayler*

221 **Satellite Digest – 163** *Robert D. Christy*

223 **Book Notices**

A FEAST OF MEETINGS

The theme of "Space Programmes for Europe" for the 18th European Space Symposium on 8–9 June is highly relevant to today's space scene. By the middle of this decade Giotto will have approached Halley's Comet, more advanced versions of Ariane will have flown, Spacelab will be well into its series of missions and a whole host of communications satellites will have taken to the skies.

The European Space Agency is in the process of formulating its projects for the end of this decade and into the 1990's: the successor to Ariane IV, possible cooperation with NASA on a permanent manned space station, planetary spacecraft, etc. It is fitting in our 50th Anniversary Year that the Society, in co-sponsorship with the DGLR, AIDAA and the AAS, will be host to the 18th ESS at our headquarters this summer, providing leading space planners and engineers with a forum to discuss the direction of Europe's space activities. Places will be strictly limited to 60, with first priority given to speakers, subject specialists and sponsoring Society representatives. It is essential to register as soon as possible. Further details are given on the back cover of this issue.

Also planned is a one-day symposium on Planetary Exploration, to be held on 5 October at HQ. Further details will appear shortly. shortly.

The Society was a founding member of the International Astronautical Federation and has consistently supported its annual congresses. Now, on reaching the 34th Congress, the venue travels to Budapest for the first time. The theme this year is "Cooperation in Space"; anyone planning to attend can obtain further details from the Society, enclosing a stamped addressed envelope.

With the European symposium in mind, what better way to open this month's magazine than with Erik Quistgaard's "New Opportunities for Man"? ESA's Director-General reviews the major forthcoming projects, including the remote sensing satellite, ERS-1, and Spacelab's successor, Eureca.

The second contribution arising from the Space '82 weekend in Brighton last November is, as we promised in the March issue, George Mueller's "Antimatter & Distant Space Flight." Dr. Mueller looks ahead to the time when Man could be travelling around the Solar System as a matter of course and, possibly, reaching out to touch the stars.

Members may remember that it was Dr. Mueller who made the first public disclosure of NASA's commitment to a space shuttle during a BIS meeting in August 1968. The Shuttle flew 13 years later but we don't expect the first antimatter trip to Barnard's Star in 1995!

COVER

This reproduction of a painting especially produced for *Spaceflight* shows a concept of a deep space vehicle powered by an antimatter rocket engine. Dr. Mueller's article on the subject begins on p.202.

Dateline Communications

В журнале не печатается ряд страниц.

NEW OPPORTUNITIES FOR MAN*

By Erik Quistgaard†

Introduction

The roots of all space research are in science and, as every scientist is only too aware, in times of recession there is a tendency for politicians to cut back on those sciences which appear to have no immediate material gain. Certainly it has been difficult despite the efforts of well-organised and well-argued space science lobbies, to persuade ESA member states to finance a science programme; as a result, it remains essentially at the level of ten years ago.

Many outstanding discoveries have come, and will continue to do so even in these highly object-oriented team-working days, by accident. Allowing scientists to "play" with electrons led to X-ray machines and unexpected medical breakthroughs.

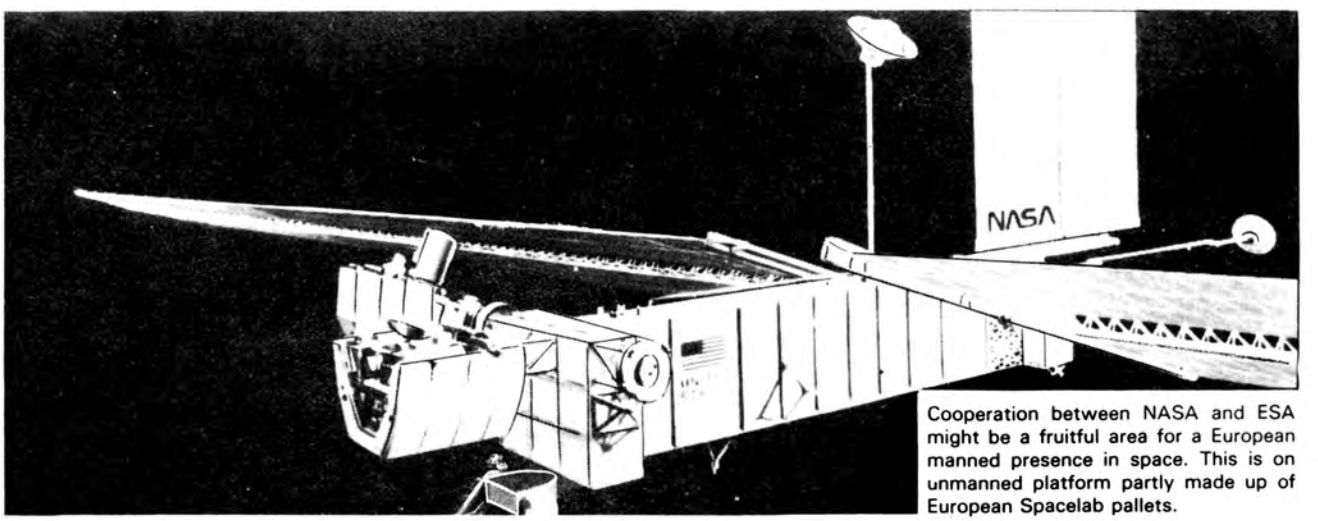
Allowing space scientists to "play" with satellites probing the magnetosphere and the solar environment has taught us that solar emissions are not constant in time and that the Sun is far from being a quiet stellar object. How far this will lead to a better understanding of weather patterns, and thereby the ability to predict major climate changes we cannot be sure.

The International Solar Polar Mission is an excellent example of a scientific idea which can catch the layman's imagination. Using Jupiter's gravitational field as a "sling-shot" mechanism to hurl the satellite into a Sun-polar orbit is science fiction come to life. Whether the data will eventually yield information of direct benefit to Mankind is to my mind only of secondary importance. What we will have done is to allow a group, or perhaps a whole community, of scientists to climb their own Everest, and to ensure that Man remains a restless being, seeking to know more of his environment and the Universe. I shall continue to press for increases in the European space science budgets as an important element of our future.

Erik Quistgaard

Digressing a moment from satellites I recall that Robert Heinlein, that classic science fiction writer, foresaw the day when lawyers, as a breed, would be eradicated from the Earth. Certainly there are times when, as an engineer, I confess to a great deal of sympathy for that viewpoint, especially when I read that some members of the legal profession have already decided that they will be indispensable *in* space, and are preparing for the day. The mind boggles at the vision of judges sitting in a special space station (doubtless named "The New Bailey") deciding on "Mars Motors versus Jupiter Jets". This is an opportunity Man must not be encouraged to take.

Perhaps, though, the lawyers grappling with the concepts of the Common Heritage of Mankind embodied in the 1979 Agreement Governing the Activities of States on the Moon and other Celestial Bodies, can



Cooperation between NASA and ESA might be a fruitful area for a European manned presence in space. This is on unmanned platform partly made up of European Spacelab pallets.

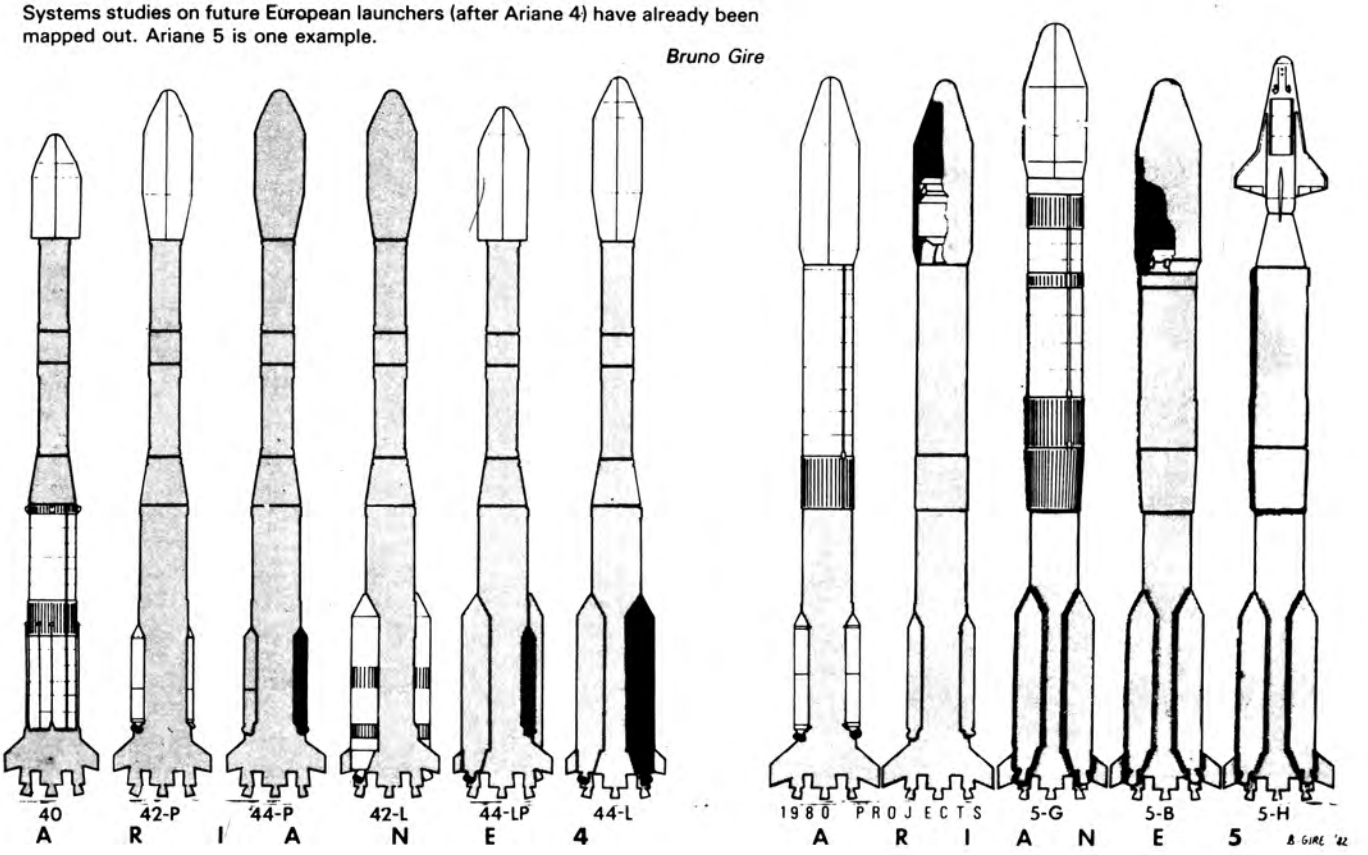
* Adapted from the author's Space '82 presentation at Brighton, November 1982.

† Director General, European Space Agency.

New Opportunities for Man/contd.

Systems studies on future European launchers (after Ariane 4) have already been mapped out. Ariane 5 is one example.

Bruno Gire



use outer space as a keystone in building new confidences, new beginnings between nations. Certainly one saw this at UNISPACE 82, and Professor Yash Pal, Secretary General of UNISPACE 82, made a very moving plea for outer space remaining an environment of peace when he addressed the IAF Conference. The United Nations is backing major proposals for studies into operational international satellite systems for meteorology and navigation, a stimulation of satellite usage for Developing Countries, and a growth in Space Information Services. All of these ideals I heartily support, and will throw ESA's weight of technical knowledge and experience in the international field behind such endeavours.

We might be opening up Pandora's box, and Yash Pal looked in and saw the possibility of an arms race in space. It would be wrong to dismiss such fears, for here is a new opportunity for Man to destroy himself, and much of the world in the process. As the major nations find themselves increasingly stalemated in the proliferation and technical advancement of weapon systems on Earth, they may seek to break the deadlock by increasing military activity in space. Those of us working for an increase in the peaceful uses of space can add a practical deterrent to that by opening to the utmost limits the opportunities for international ventures in space.

In what way can Europe contribute? We have seen, over the last few years, a rising interest in Europe in microgravity research. The life and material scientists have seen the potential of Spacelab, and beyond that the possible derivatives, and the opportunities these vehicles offer.

For the moment our aim in life sciences is to support basic research; to seek for a better understanding, in some cases a first understanding, into the effect of gravity on physiological mechanisms and processes. In the cardiovascular investigations we seek to learn more of the way in which the central circulation system is gravity-dependent, in the belief that this might take us on to understanding more about high blood pressure diseases and the mechanisms for defeating them. One must not raise false hopes, but somewhere downstream, say in ten years, we may begin to see a medical outcome.

Using SLED, life scientists hope to learn more of the detailed interplay of systems of the inner-ear, and the optical-tactile interplay which is not yet understood. Our technology is already in use on the ground: the SLED helmet is being used in a clinic on an experimental basis. Our investment in basic science includes endocrinology, the human sensory motor system and the metabolic system. This latter may be very important if we can see the degree to which mineralisation processes in the body are gravity-dependent. In the next decade it may help doctors to combat bone brittleness in long-term bedridden patients.

The biologists are studying cell and developmental biology and embriology to find out in both plants and humans at what level and where gravity plays a key role. The spin-off could well be the ability to manipulate cells at a very early stage. To the biologists this could

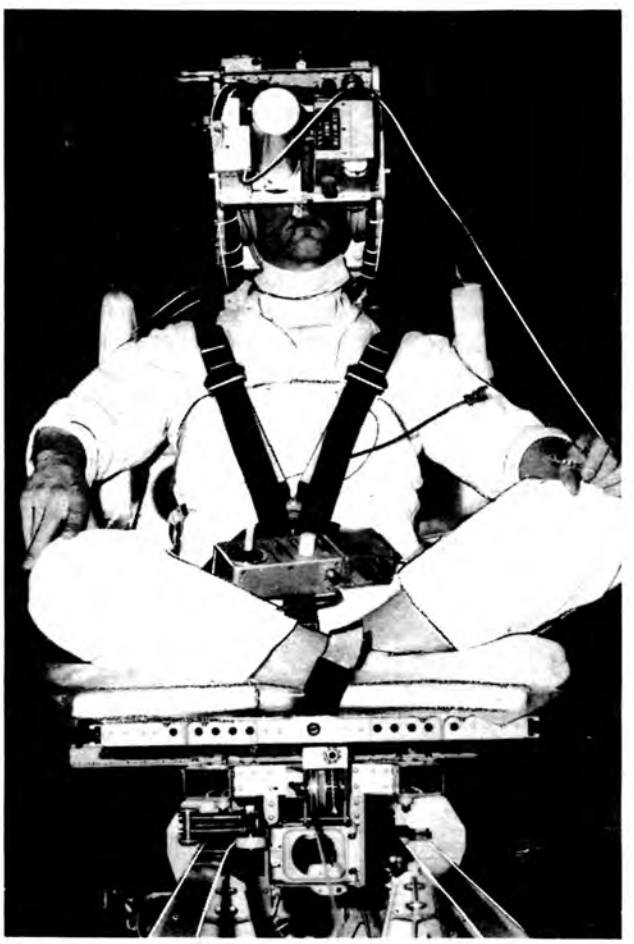
be another "newtonian" level of breakthrough.

It is so easy to forget that we are fighting gravity all our lives; the effects of zero-g are not always realised. A sneeze may mean nothing but an on-coming cold on Earth. An inadvertant sneeze in space could rocket an astronaut into eternity!

The First Spacelab Payload in October 1983 will carry with it the hopes of many material scientists too. The Materials Science Double Rack contains four Multi-User Facilities: the Isothermal Furnace, the Gradient Furnace, the Mirror Furnace and the Fluid Physics Module. Between them they will carry 14 metallurgical, nine crystal growth and seven fluid-physics experiments. In addition there is a cryostat with one protein crystal-growth experiment, a high-temperature thermostat with a diffusion in metallic melt experiment, and an ultrahigh vacuum chamber to experiment with the adhesion forces of metals.

Material scientists cover a wide range of disciplines, but they have a common denominator in their wish to seek opportunities in space where there is almost a complete absence of sedimentation and buoyancy, gravity-driven convection and hydrostatic pressure.

While it is generally acknowledged that we should be able to produce materials of higher strength, and more homogeneous, faultless crystals, comments are levelled at us that quantities can never be sufficient to justify the cost. I believe we can answer that accusation in three ways. First, until we know more definitely what we can do, we do not have the basic data on which to assess future capabilities. Secondly, we can already see a trend towards those materials being needed in high quality, but in low quantities. And thirdly, a point often forgotten, we hope to gain the data which will tell us more of gravity's role, so that we can try to improve processes in Earth-bound industry. Certainly a number of industrial firms are backing this research, and we can expect the industrial lobby to increase its interest.



Space SLED is designed to study vestibular behaviour of humans in weightlessness; it might help to discover why so many astronauts are prone to space sickness. The seat travels along the rails while the helmet and other equipment measure the occupant's response (eye movements, etc).

Beyond Spacelab

I have already mentioned Spacelab, so I will make a few comments on Eureca, the likely next step. I will not prejudge the outcome of studies into the actual configuration which are reaching their concluding stages at present, but will look instead at the underlying principles and aims of the system.

Eureca is a payload carrier which can be separated from the Shuttle in orbit, operate in a free-flying mode, be retrieved and then reused. For the first flight a microgravity payload is proposed as the primary and the design-driving payload. Included in the development will be a material synthesis facility.

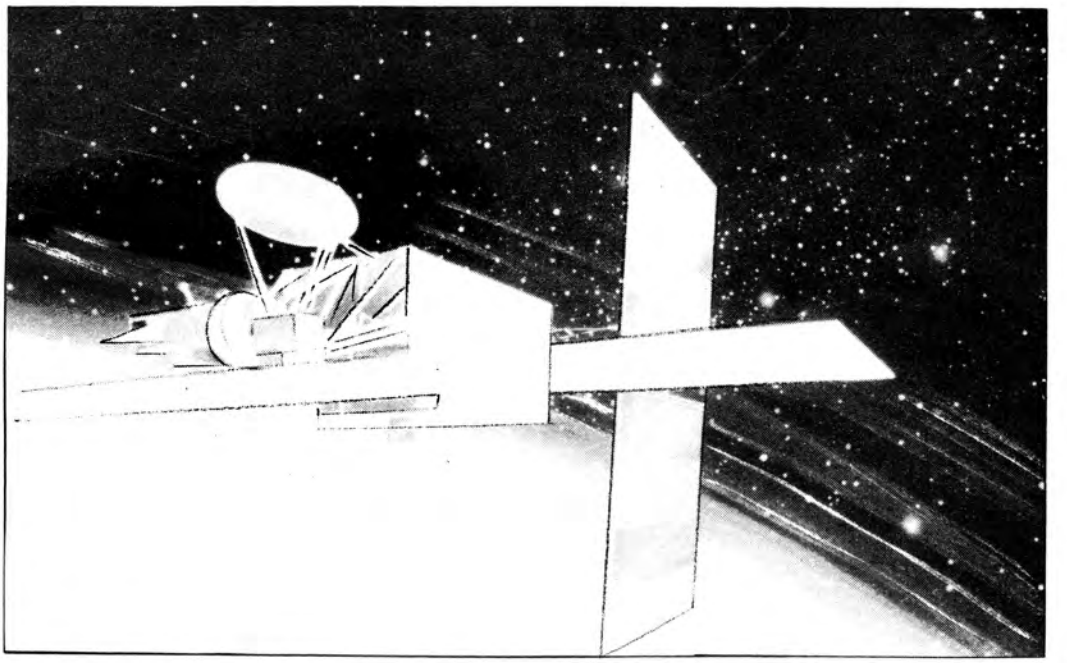
The overall objective is to provide a carrier in low Earth orbit for those users for whom retrieval of experimental samples is necessary, such as in most microgravity experiments, or for whom retrieval and re-use of costly equipment is desirable, such as telescopes. In this day and age one must be very conscious of costs, and Eureca will be made cost effective by developing the elements from existing hardware and, of course, it can be re-used.

We look forward to a first launch at the end of 1986 or early in 1987, with possible missions to follow in astro- and solar physics, Earth observations and space manufacturing demontrations.

Looking still further ahead, Eureca, plus rendezvous and docking techniques allied to robotics and an automated return capability of capsules, could take us into the realm of unmanned space stations by the end of the millenium.

One debate which continues, and is likely to do so for some time to come, is that of the value of continuing with, and expanding manned space flights. The emotional and political arguments of the 1960s are well known, and there are those who suggest that today's USSR and USA manned flights owe more to political than economic considerations. Those who believe we cannot afford both often point to the considerable progress in robotics and artificial intelligence to support a thesis that Man is an encumbrance in space, with his special needs of breathable atmosphere, food and hygiene, and rescue requirements. Others counter this by suggesting that it is Man's ability as a skilled and versatile construction worker, his practical training, his pragmatism, his motor-sensory coordination, and not his intellectual capacities, that fit him for a future in space when macro-engineering projects are attempted.

Europe will take part in this debate and, unless there



ERS-1 (see text below) will help the fishing industry, among others, from 1987.

MATRA

is such a strong concensus in favour of either manned or unmanned space systems, will attempt to explore three avenues for the future, within the financial constraints set by the member states.

Systems studies on future launchers have been mapped out. Phase 1 is to define launcher concepts possible after Ariane 4, with studies of propellents, rocket engines and hypersonic aerodynamics. Phase 2 consists of feasibility studies and the selection of a preferred launcher, followed in Phase 3 by programme definition.

The second avenue is a European In-Orbit Infrastructure. By reviewing future European mission trends and needs, preliminary concepts of an IOI are expected, possibly followed by a demonstration mission. This might well be a rendezvous and docking mission with Eureca as one element. Other elements to be studied include robotics, re-entry and in-orbit manoeuvring vehicles.

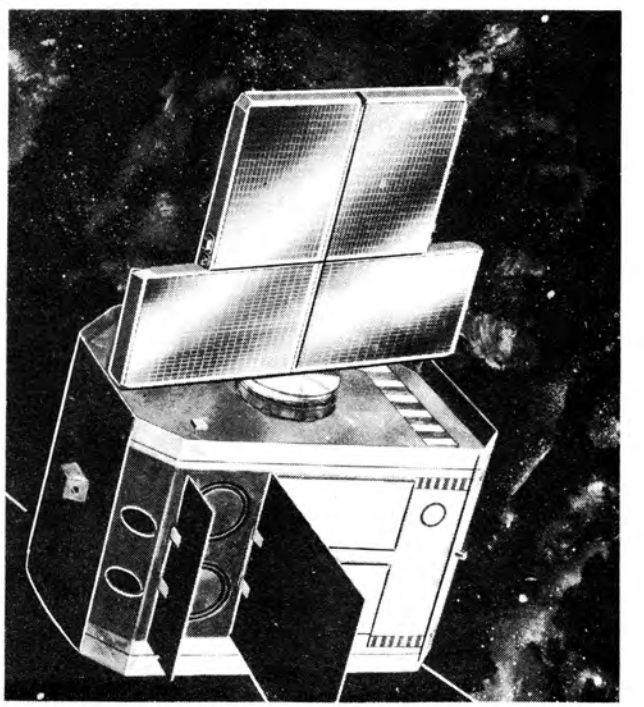
The third avenue is co-operation with the US in manned space systems. A study on European Utilisation Aspects of a US manned Space Station should tell us which European missions can be supported by a space station. Money is being allocated to support the participation of European industry in NASA Space Station studies; in particular the use of such relevant European technology as Spacelab will be promoted.

Remote Sensing

One area in which Europe does intend to play an important role is Earth observations. The ESA Council has authorised work on the first European remote sensing satellite, ERS-1.

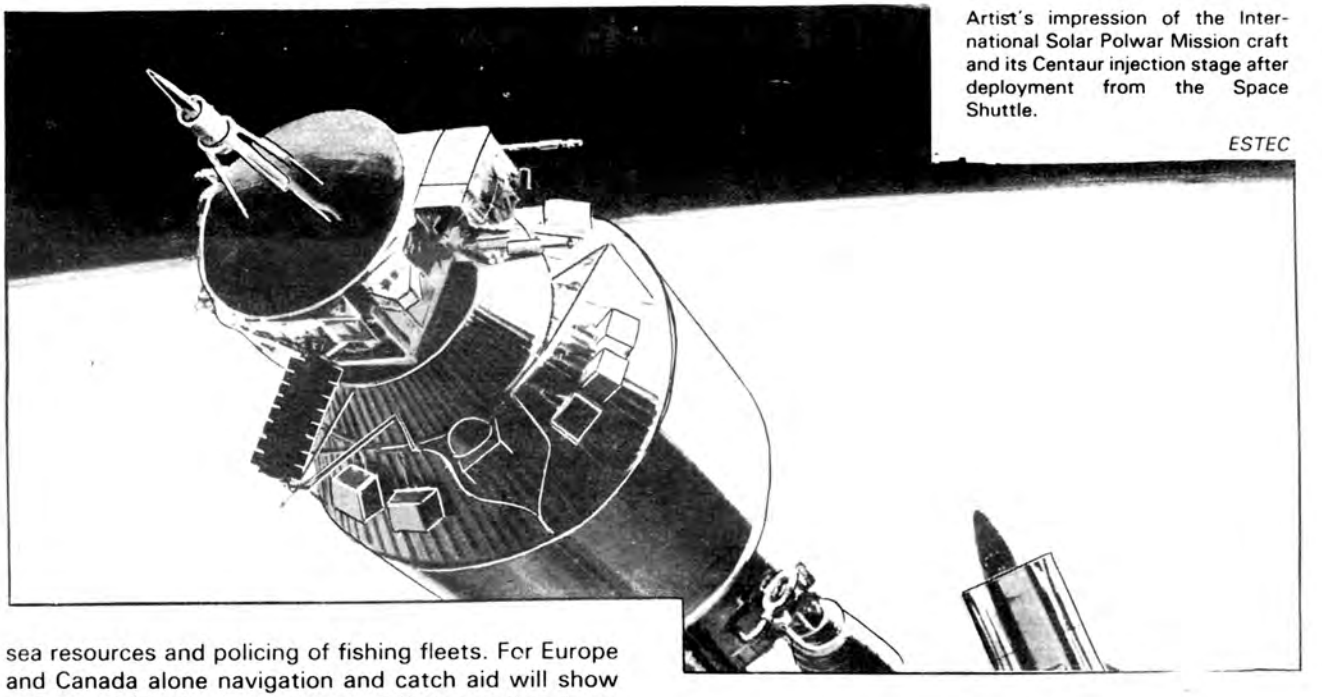
ERS-1 is an ocean surveillance satellite carrying active microwave instrumentation and a radar altimeter. Here I can predict with more certainty the benefits we can expect. The images produced by the Synthetic Aperture Radar will cover ice-loads in the Arctic and Antarctic water ways, coastal areas with dense ship traffic, oil slicks, and even zones with underlying sea-floor topography of particular relevance. The wind scatterometer offers a network of wind observations many times more detailed than achievable by surface vessels. A wave sensor is also included. An operational ERS system would most likely carry an Ocean Colour Monitor, a scanning sensor working both as an imaging spectrometer in the visible and near infrared, and as a radiometer in the thermal infrared.

Fishing would benefit not only from navigational aid, but also in fish catch, long-term management of living



Exosat, the European X-ray satellite, will be launched this year following delays caused by the failure of Ariane L5 last September.

MBB



Artist's impression of the International Solar Polwar Mission craft and its Centaur injection stage after deployment from the Space Shuttle.

ESTEC

sea resources and policing of fishing fleets. For Europe and Canada alone navigation and catch aid will show savings of $10.3 million a year. Off-shore oil and gas operations would be expected to benefit from 1990 onwards, in exploration, off-shore development and exploitation to the tune of $33.8 million a year, and pollution monitoring could provide $30.5 million of savings. These are optimistic figures, and applying a credibility index, we can expect an actual saving of $56.1 million a year against the cost of an operational system of $40.7 million. Over a 10-year operational period, we could therefore expect $154 million in savings.

Although ESA's first ERS satellite is ocean-oriented, we have already carried out studies into the economic benefits of a future European land observation satellite system. One could assume that knowledge of European agriculture was well organised. It turns out that crop forecasts currently available are neither very timely nor very accurate. They are published only twice a year, and they are not consistent between EEC countries. By remote sensing methods it would be possible to make earlier predictions of yields, earlier acreage measurement for the main crops, better inventory management, better soil utilisation, quantification of natural and Man-made disasters, and evaluation of the scope and cause of crop failures. For cereals alone the potential benefit to EEC countries has been calculated as between $220 and 450 million a year. This is a benefit/cost ratio of not less than 4:1.

Nor should one forget the opportunities presented by remote sensing techniques for the advanced nations to help the Developing Countries. One lesson to be learnt from recent experiences, however, is that providing such nations with rapid and sophisticated crop information is no use if we have not also provided the logistics, the ground infrastructure, the scientific and technical training of personnel and even, in some cases, the psychological training to withstand cultural prejudice and pressures. New opportunities in space are sometimes severely limited by Man's lack of preparation to grasp the opportunity back on Earth.

Communications

Here, business has the objective of combining all forms of electronic communication, including voice traffic, electronic mail, facsimile transmission, audio- and teleconferencing, and ordinary data transmission to make the most efficient use of each circuit. With expenditure on telecommunications in the USA's top companies expected to reach $13,000 million in 1985, it is to be expected that they see systems offering them control as well as services as attractive. By means of its multiservice channels, ECS-2, and later L-Sat, will provide the components for such services.

The all-in conference and document transmission facility has many advantages, not least that travel costs and fatigue are cut drastically. A conference will cost only the Man-hours taken, and not two days travel, plus the resultant loss of efficiency. We are told that Man, being the perverse animal he is, will never accept this substitute for the face-to-face encounter. I prefer to believe that Man will once again prove the flexibility of nature which he has shown so often in the past.

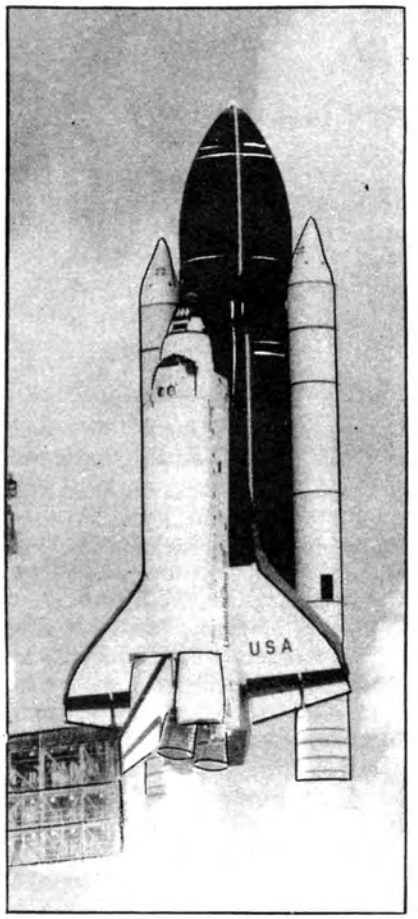
There is a reverse side to this coin. So many traditional ways of communication, especially business travel and mail, will suffer corresponding losses, and the industries which back them up may be severely hit by the 1990's.

President Kennedy, when talking about space programmes, used to tell the story of the Irish boys who, faced with an orchard wall that seemed too difficult to climb, tossed their caps over . . . and then they had no choice but to follow. For those of us who are dedicated to taking Europe as an entity forward into the future, the story remains very relevant and poignant. We have thrown our scientific, technical and political caps over a wall, and now we climb it, not always easily, but at least with the sure belief that once on top we shall explore the wonders on the other side.

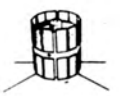
TEST YOUR SPACE KNOWLEDGE

How closely do you follow space affairs? If you read *Spaceflight* from cover to cover every month then you'll be well prepared to tackle most of the questions below. Some may need a little thought. The answers are on p.224.

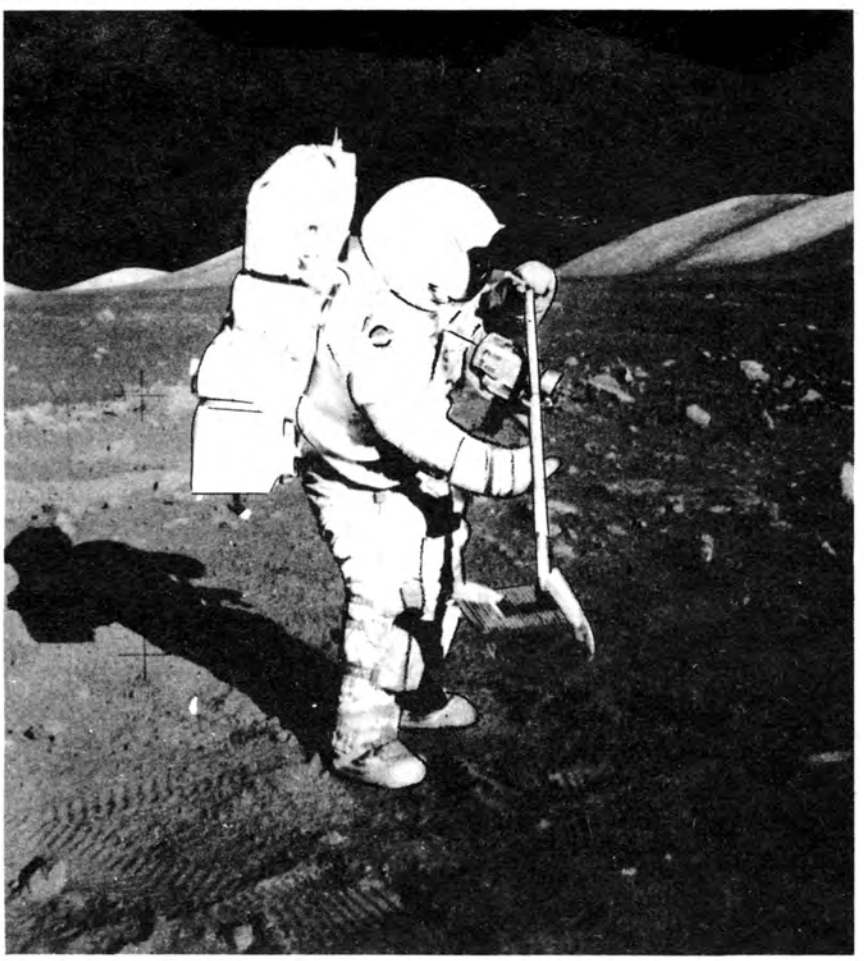
1. In what year did the first liquid-propellant rocket fly?
2. Which moon of Jupiter has active volcanoes?
3. What is the name of the European Halley's Comet probe?
4. Who else will be sending probes to Halley?
5. When was *Spaceflight* first published?
6. What is the name of Pluto's moon?
7. When was the first Saturn 5 launched?
8. Which probe, and in what year, sent back the first picture of Venus' surface?
9. What was the total weight (kg) of lunar samples returned by the Apollo missions: (a) 281, (b) 381, (c) 421?
10. When did the Skylab space station reenter?
11. What is the diameter of the Space Telescope's main mirror?
12. Which probe, and in what year, first flew past Jupiter?
13. Who made the first space walk?
14. When was the first 4-man space mission launched?
15. Which was the first probe to visit more than one planet (other than Earth!)?
16. Name the third and fourth Shuttle Orbiters.
17. Name all of the Apollo Moonwalkers.
18. What is L-Sat?
19. Which rocket stage was the first to use liquid oxygen/liquid hydrogen in space?
20. What was the target star of the BIS Daedalus study?
21. What would the orbital period (minutes) be of a satellite skimming the Earth's surface (no atmosphere!): (a) 64, (b) 74, (c) 84?
22. Which manned missions were in space during Christmas of (a) 1968, (b) 1973?
23. Which Landsat Earth resources satellite was launched last year?
24. In what year was the first manned rendezvous and docking achieved?
25. How many crews visited the Salyut 6 space station?
26. In which year did Yuri Gagarin die?
27. Which is the largest moon in the Solar System?
28. When will Voyager 2 reach (a) Uranus, (b) Neptune?
29. Which is the most distant known planet from the Sun?
30. What is SPOT?



The Space Shuttle. See question 16.



On the Moon with Apollo. See questions 9 and 17.



NEWS FROM THE CAPE

By Gordon L. Harris

FY 1984 BUDGET

NASA unveiled its FY 1984 budget (effective from 1 October 1983) at a press briefing on 31 January under rather unusual circumstances. Usually, like other Federal agencies, NASA held embargoed briefings two days before a Presidential budget was handed to the Congress. Press handouts were dated 29 January, indicating NASA planned to continue that policy. But the briefing actually took place after President Reagan's spending plan became public.

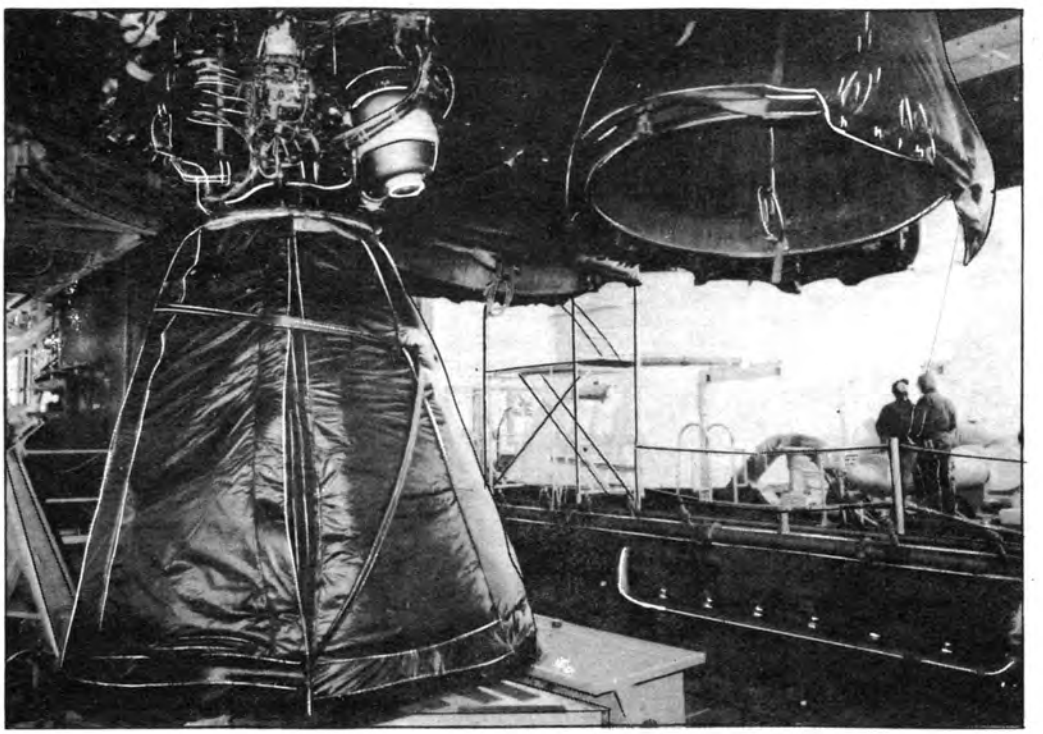
Administrator James Beggs spoke of a "constrained" budget, adding that it reflects Reagan's commitment to a strong national space and aeronautics programme. There may have been implications in Beggs' opening remark concerning "NASA's obligation to help strengthen the national security and maintain US leadership in space and aeronautical technology . . ." which placed priority on military requirements.

The budget is $7,100 million or 4 percent higher than FY 1983. Eighty percent of the total, $5,700 million, is requested for research and development. Sixty one percent, or $3,500 million, of that will be spent for STS, including Shuttle production and operation, upper stages for Shuttles, Spacelab, the US-Italian tethered satellite system, expendable vehicles and other support equipment. Why the agency considers production money as part of its R&D programme was not explained.

Beggs said that parcelling out the $3,500 million reflects a trend begun last year to spend more on Shuttle operations and less on capability development (a term for upgrading Orbiter performance and a new Centaur-based upper stage which was turned down several years ago). So "capability" will require $1,900 million ($2,100 million in FY 1983) and "operations" $1,600 million, an increase of $100 million. Shuttle

NASA FY 1984 BUDGET PLAN (in $1,000).

	FY 1983	FY 1984
STS capability development	2,144,100	1,927,400
STS operations	1,453,700	1,570,600
Physics & astronomy	441,000	514,600
Planetary exploration	186,400	205,400
Life sciences	55,700	59,000
Solid Earth observations	132,200	74,400
Environment observations	156,900	163,000
Materials processing	22,000	21,600
Communications	32,400	21,100
Information systems	7,500	8,900
Aero research & technology	280,000	300,300
Space research & technology	123,000	138,000
Tracking and Data Acquisition	498,900	700,200
	5,542,800	5,708,500
Shuttle production & capability development	1,729,300	1,500,000
Upper stages	167,000	143,200
Spacelab	121,200	119,600
Technical base	70,300	93,100
Payload operations & support equipment	44,400	53,200
Advanced programmes	11,900	15,000
Tethered satellite	—	3,300
Expendable vehicles	83,000	50,000
Shuttle operations	1,370,700	1,520,600



Challenger's main engine no. 2011 was removed on 4 February because of a hydrogen leak. A further picture can be found in this month's "Space Report".

News from the Cape /contd.

Shuttle STS-7 astronauts practise their emergency fire fighting skills at the Cape. Left is John Fabian; far right is Sally Ride (both Mission Specialists); the others are instructors.

NASA

funding for the new year will permit:

- five flights in FY 1983, eight to nine in FY 1984, including the first rendezvous and repair of a satellite in orbit (the Solar Maximum Mission satellite);
- completing the fourth Orbiter and purchase of spare parts for the four-Orbiter fleet;
- first Spacelab mission and preparations for a second in FY 1984;
- new facilities for increasing Shuttle flight rates;
- joint NASA-Air Force programme to modify Centaur and complete the Inertial Upper Stage to launch TDRSS (Tracking and Data Relay Satellites);
- continued procurement of Shuttle tanks, Solid Booster Rockets and other flight hardware
- beginning hardware development for the tethered satellite that will permit flying experiments up to 100 km from the Orbiter.

The budget proposal includes:

- a project to map Venus using radar imaging at much less cost than the Venus Orbiting Imaging Radar authorised (but not funded) by Congress in 1982:
- an advanced communications technology satellite to develop and flight test high risk technology. This will be financed with industry participation, reducing government outlay;
- a numerical aerodynamic simulation capability project;
- a large computer system which will have "major impact on aircraft design, improving accuracy and reliability while cutting down on long and costly wind tunnel and flight testing. This requires $300 million compared to $20 million in 1983.

Beggs referred to the National Transonic Facility at the Langley Research Center in Virginia which will open in June. It is, he added, the most advanced transonic speed test facility in the world.

The budget continues development of the Space Telescope (Shuttle launched and tended), a Galileo orbiter and probe to Jupiter, the International Solar Polar Mission (with Centaur in 1986), a Gamma Ray Observatory in 1988 and support of Pioneer Venus Orbiter, Pioneers 6 to 11, and Voyagers 1 and 2. Funding will continue the level of employment at NASA centres.

What the budget does *not* support is perhaps just as interesting. There is no funding for a fifth Shuttle Orbiter. Of that, Beggs replied to a press query that NASA's Shuttle traffic projections do not justify another ship. He mentioned Ariane's competition in the same response. Nor is there a commitment for a large space station, staunchly advocated by NASA spokesmen for several years. Instead there will be more studies added to those already completed and more under way.

Said Beggs, without evident relish, "We have no specific plans to establish a permanent manned station in orbit. We are continuing planning and study efforts. These studies centre on potential user requirements, potential hardware and software systems, potential science applications payloads and an overall architecture which could accommodate specific missions."

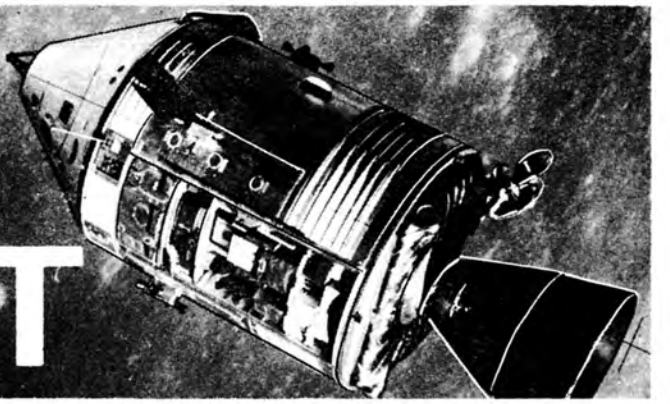
The administrator's statement was obviously prepared well in advance of *Challenger*'s engine problem that will affect the 1983 flight schedule. Even the planned September liftoff of Spacelab in a modified *Columbia* is now in doubt.

LAUNCH CONTRACTS

Hoping to reduce Shuttle launch costs, the Kennedy Space Center issued a request for proposals on 20 January which will result in the selection of a contractor to process Shuttles here and at the Vandenberg Air Force Base in California. The latter is expected to commence operations in 1985.

Meanwhile, KSC extended its contract with United Space Boosters to 30 September 1983 at a cost of $13,860,875. USB assembles and checks out Shuttle booster segments and associated hardware throughout pre-launch, launch, post launch recovery and disassembly.

SPACE REPORT



BEYOND SPACELAB AND ARIANE

1983 is ESA's "Spacelab year": Europe's efforts over the past ten years will come to fruition this autumn with the first Spacelab mission. As a follow-on, work has been proceeding over the last two years on possible ESA activities in the Space Transportation field for the late 1980's and 1990's. In 1982, the Spacelab Follow-on Programme, covering the development of a European retrievable carrier, Eureca, got underway. 1982 also saw the start of Ariane 4 development designed to meet needs for more powerful launchers from 1985.

Ariane 4 and Eureca represent the completion of Europe's Space Transportation Systems Programme as it was planned ten years ago. The time has now come to decide on future European needs in this area. A number of European States have now entrusted the Agency with a new programme – the Space Transportation Systems Long Term Preparatory Programme (STS-LTPP) – which covers the study of the different options beyond Ariane and Eureca in sufficient detail to enable Europe to lay down a long-term policy and thus to decide on new Space Transportation programmes before the end of 1985. On 14 January nine ESA Member States had subscribed to this new programme, providing the required 75 per cent of the total financial envelope (about $11 million in 1983 terms) to enable the programme to get underway.

The STS-LTPP deals with three main themes:

Maintaining an independent launch capability to meet the requirements of European and other users, competitive with other systems (eg the US Shuttle);

The capability of carrying out orbital operations developed either independently or in cooperation with NASA. A combination of an in-orbit system with an advanced European launcher would enable Europe to carry out Shuttle-type missions with, for example, satellite repairs and return to Earth;

Maintaining Europe's access to manned systems, begun by Spacelab, both by taking part in US space station activities and by studying the evolution of a European in-orbit system towards manned capability.

Such studies have already started; towards the end of 1982 some contracts for preliminary studies on possible European participation in the US space station programme were awarded. In parallel, other contracts were placed in industry aimed at defining future European launchers beyond Ariane and systems for in-orbit services (docking, assembly, satellite repairs, etc.).

NEW ASTRONAUT GROUP?

It appears that NASA might call for applications for Shuttle astronaut candidates this year, writes Dave Shayler. The first two Shuttle groups, of Pilots and Mission Specialists, were selected in 1978 and 1980 and are now seeing flight experience. The new 1983 group would undergo a 12 month training course to make them eligible for missions beginning in about 1985. By then many of the pre-Shuttle era astronauts will have retired and the job of flying the reusable spacecraft will have passed on to the newer groups.

MID-AIR RECOVERIES

Experiments launched on 13 January aboard two single-stage Orion sounding rockets were successfully captured in mid-air, allowing them to be used on future flights. Obtaining measurements of nitric oxide concentrations in the middle and upper stratosphere (30–50 km), both experiments had already flown on three previous occasions.

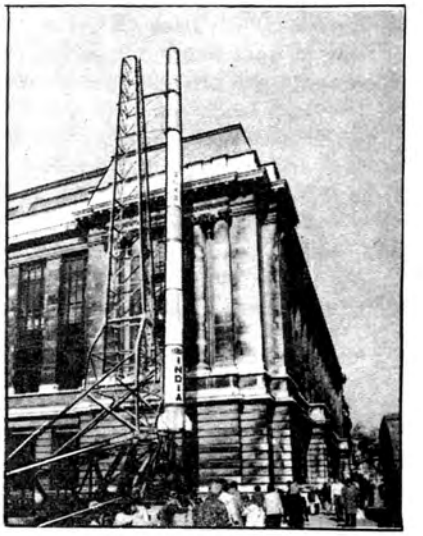
Recovery of the experiments was made at the Wallops Island site by a Skyvan aircraft equipped to hook the parachutes and winch it and the payload aboard.

The first experiment reached an altitude of about 70 km, separated from the rocket near apogee and was caught some 97 minutes later.

RADIO EXPERIMENT

An experiment to investigate amplification of long wavelength radio waves in the magnetosphere was recently completed using the S81-1 experiment, the 33rd in the USAF's Space Test Program, writes Joel Powell. S81-1 is an add-on package of the Big Bird reconnaissance spacecraft launched on 11 May 1982.

The SEEP (Stimulated Emission of Energetic Particles) experiment showed that long wavelength signals were amplified in the Earth's Van Allen radiation belts before returning to the ground. This effect could be used in more effective low power radio communications with submerged US Navy submarines. Transmitters in Maine, Maryland, Washington and the Antarctic were used to send up signals as the satellite passed overhead, watching for interactions with particles in the magnetosphere.



London's Science Museum now has a full-scale model of an Indian SLV-3 satellite launcher on external display.

Science Museum

INMARSAT GROWS

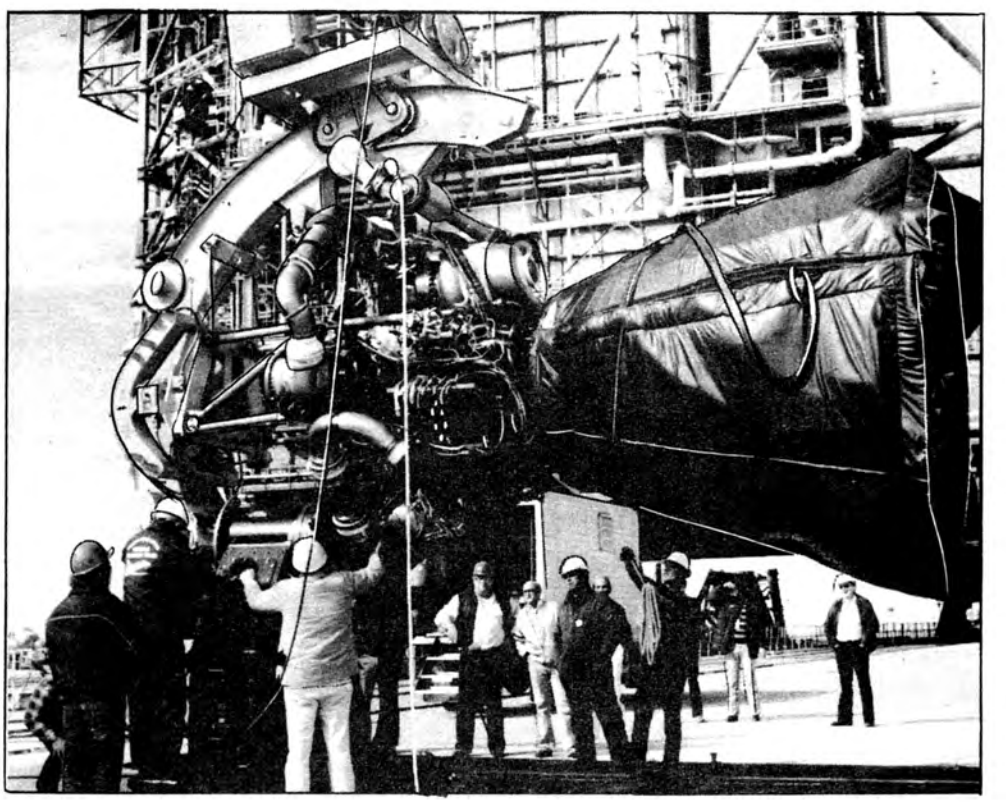
The United Arab Emirates became the 38th country, in January, to join the International Maritime Satellite Organization (INMARSAT). With the financial backing of its member countries, INMARSAT provides telephone, telex, facsimile and data services *via* satellites to the shipping and offshore industries around the world.

MUSEUM'S SPACE GALLERY

The Science Museum in London is planning to open a much larger space section towards the middle of this decade. Work has been in progress for around 15 months and will continue towards a provisional opening date of 1985. The new gallery will occupy around 1000 sq metres on the third floor close to the Aeronautics gallery and will trace, primarily, the development of unmanned space exploration under such headings as "The History of Spaceflight", "Rocket and Satellite Technology" and "Space Applications". The manned programme will be covered in a smaller section since it already occupies a large area in the Exploration gallery on the ground floor.

MORE SKYLARKS

British Aerospace are to supply a further five Skylark 7 research rockets in component form to DFVLR, Germany's national aerospace research organisation. This follows the continued success of Germany's Texus



Shuttle main engine 2011 is removed from Orbiter *Challenger* because of a hydrogen leak (see this month's "Milestones"). Engine 2016 was moved in from the National Space Technology Labs in Mississippi to replace it but that, too, was found to leak, this time with oxygen.

NASA

programme which uses Skylarks to test experiments for flight in Spacelab. Each rocket can carry numerous experiments and provide over six minutes of low gravity. They are launched from the Swedish Space Corporation's extensive range at Kiruna in Sweden where the payloads are parachuted safely to Earth at the end of the flight and recovered by helicopter.

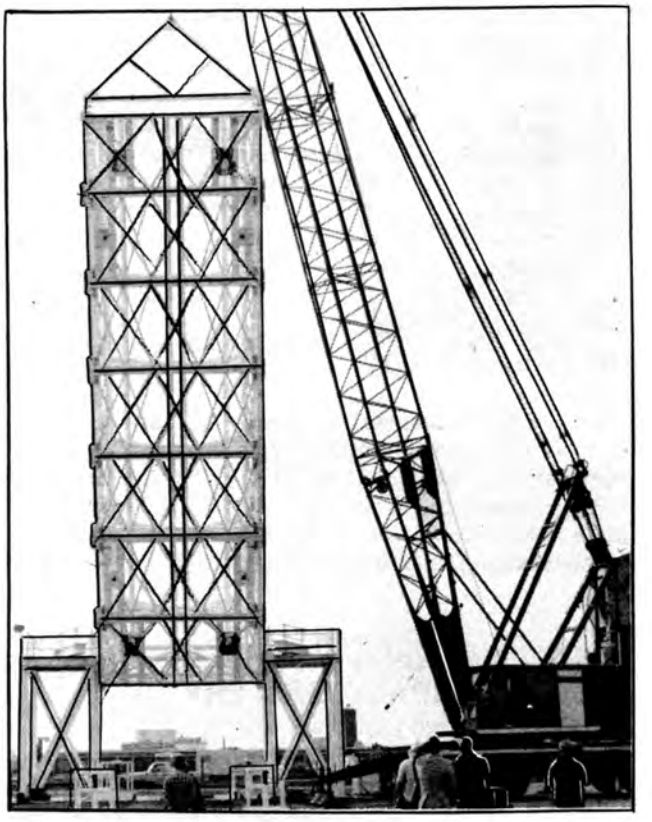
For many years Skylark was the backbone of the UK's space research programme, the first being launched from Woomera, Australia in 1957. By mid-January this year, a total of 386 had been launched.

INTELSAT DEMAND UP IN 1982

Last year saw another large increase in demand for international communications services *via* INTELSAT. Demand for TV broadcasts through the network of 17 satellites increased by 42 percent during the year, totalling 50,574 half-channel hours, as compared to 35,658 in 1981.

Also on the rise was the demand for leased services to provide communications to countries within their own borders. Domestic leases increased to 40 in 1982, up from 26 in 1981. In terms of leased bandwidth, the growth was 90 percent, from a total of 720 MHz at end-1981 to a total of 1368 MHz at end-1982.

INTELSAT, whose membership now totals 108 countries, has been at the forefront of international communications by satellite since its establishment in 1964. Its services are available to all countries on a non-discriminatory basis.



Since the Shuttle can land at a number of emergency sites around the world, NASA has produced this cradle to handle payloads after such landings. It can be divided into sections and flown to wherever it is needed to protect and transport payloads.

SHUTTLE LAUNCH SCHEDULE

As the rate of Shuttle launches increase, the number of astronauts and payloads going into space will rise dramatically. *Spaceflight* will publish occasional lists of the missions and their crews, updating them when necessary. Here is the first:

FLIGHT/ORBITER/ LAUNCH/ DURATION	CREW	PAYLOAD
STS-7 *Challenger* May/6d	Crippen, CDR, 1 Hauck, P Ride, MS Fabian, MS Thagard, MS	Telesat-F Palapa B-1 SPAS-01 OSTA-2
STS-8 *Challenger* July/3d	Truly, CDR, 1 Brandenstein, P Bluford, MS Gardner, D., MS Thornton, MS	TDRSS-B Insat 1B
STS-9 *Columbia* 30 Sep/10d	Young, CDR, 5 Shaw, P Parker, MS Garriott, MS, 1 Lichtenberg, PS Merbold, PS (ESA)	Spacelab 1
STS-10 *Challenger* 14 Dec/?d	Mattingly, CDR, 2 Shriver, P Buchli, MS Onizuka, MS ? AFSE	DoD 84-1 (Teal Ruby)
STS-11 *Challenger* Jan. 1984/7d	Brand, CDR, 2 Gibson, R.L., P. McCandless, MS Stewart, MS McNair, MS	Palapa
STS-12 *Discovery* Mar. 1984/5d	Hartsfield, CDR, 1 Coats, P Resnik, MS Hawley, MS Mullane, MS *? PS*	TDRSS-C

CDR: Commander; P: Pilot; MS: Mission Specialist; PS: Payload Specialist; AFSE: Air Force Space Engineer. Number after crew position indicates number of previous missions.

Telesat-F, Palapa and Insat 1B are communications satellites, SPAS-01 is a German experimental platform, OSTA-2 is a NASA science payload, Spacelab is the NASA/ESA laboratory, and Teal Ruby is a US Air Force test payload for tracking aircraft by infrared.

Crippen will be the first man to fly in the Shuttle twice; Sally Ride will be the first US woman astronaut; Ulf Merbold will be the first ESA astronaut; and John Young will be the first to make six space trips.

JAPAN: FIRST WITH DBS

By Neil W. Davis

The US, Germany and France are all planning to orbit Direct Broadcasting Satellite (DBS) systems within the next few years. But the first operational DBS will be launched from the southern Japanese island of Tanegashima. In May 1984, Japan will begin direct TV transmissions to household dish antennae throughout the Japanese archipelago.

Introduction

The Japan Broadcasting Corporation (NHK) has been researching into broadcasting satellite technology since 1965. NHK and Japan's major space organisation, the National Space Development Agency (NASDA), conducted tests with the "Broadcasting Satellite Experimental" after its launch in 1978 from Cape Canaveral. The BS-2a, to be launched in February 1984, and the back-up BS-2b, scheduled for August 1985, are basically similar to BSE. Similarly, they will be placed in geostationary orbits at 110° East. BSE was used to test out the technology for an operational DBS system, and NASDA can now launch these 350 kg craft instead of relying upon foreign rockets.

The Objectives

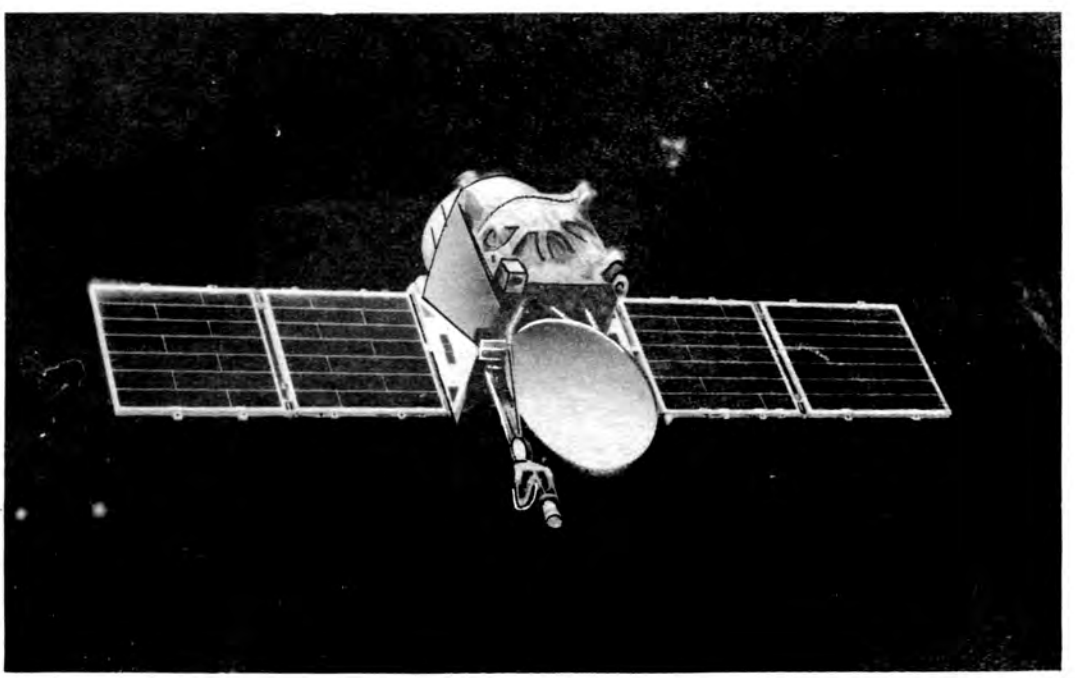
The main aim is to provide ready access to the general and educational NHK channels for more than 400,000 households which are currently without conventional TV access. Japan consists of four principal islands and hundreds of smaller remote islands, all of which are rugged. Thus there are many areas without normal TV service. As a government organisation, NHK has to offer its services to all Japanese households; the only way is to use DBS.

Earthquakes and typhoons frequently strike Japan, and the government is planning to use the BS-2 system in such emergency situations. The Tokyo area is expecting another massive earthquake within the next decade and DBS would help the emergency services enormously.

The actual satellites are being built by General Electric in the US. The parent of NASDA, the Science and Technology Agency (a governmental ministry) has decreed that all NASDA satellites must have Japanese "prime contractors." Toshiba is building some of the antenna systems, but over 70 per cent of the work will be done by General Electric, including the three-axis control system.

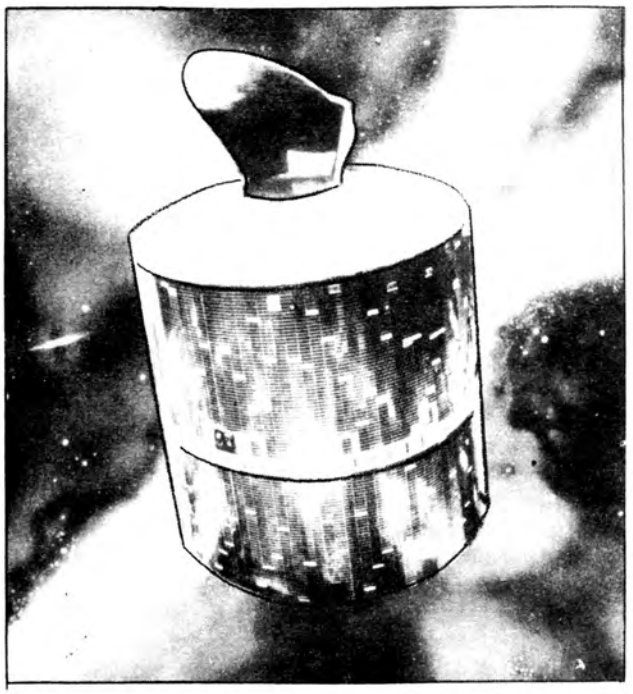
The two satellites will be operated by yet another governmental agency: the newly-formed Telecommunication Satellite Corporation (TeleSat-Japan). Following three months of testing in orbit by NASDA, the craft will be turned over to TeleSat-Japan for use.

The launch weights of the identical BS-2 satellites will be 670 kg before the firing of their Thiokol-STAR Apogee Kick Motors. NASDA N-2 boosters will be used from the Tanegashima Space Center (250 km southeast of Nagasaki). The N-2 is a Delta-based second-generation Japanese vehicle. The BS-3 satellites, planned for 1988, can be larger because the third-generation H-1A vehicles will be available, capable of injecting a 550 kg satellite into geostationary orbit. The BS-2 solar array measures 8.9 m in total length, compared to the 19 m of the French TDF-1 and the German TV-SAT. These French and German satellites will weigh about 1,190 kg in their final orbits, more than three times the weight



The BS-2 satellite.
NASDA

Japan: First with the DBS/contd.



Communications Satellite-2 (CS-2) is another pair of Japanese satellites, this time to provide non-DBS services.

of BS-2. The six COMSAT-STC satellites will weigh 650 kg.

Most of the TV programmes will come from the NHK-Tokyo Broadcasting Center; others from NHK's secondary facility at Osaka. Some programmes will be locally produced and transmitted direct from transportable Earth stations scattered about Japan. Although the main BS-2 objective is to provide direct reception, NHK will also use them to transmit to repeater stations, which upon reception will re-transmit through conventional UHF.

The Japanese electronics industry has cooperated with the NHK Technical Research Laboratories to develop the small and relatively inexpensive home receivers. A unit will include a paraboloidal antenna just under 1 m in diameter, an attached SHF/UHF down converter unit and an indoor demodulation device. Reception tests with snow-covered antennae and those subjected to fierce winds were conducted with BSE. Japan's northern island, Hokkaido, has a harsh winter climate, and the southern islands are frequently hit by typhoons during August and September.

High Definition Television System (HDTV) experiments, to produce sharper pictures, began with BSE, and NHK is currently planning tests with BS-2 in order to pave the way for an operational system with the BS-3 or BS-4 series. The early 1990's should see 1,125 line TV. Stereo sound will also be investigated with BS-2.

OUT NOW – A NEW SOCIETY BOOK

THE EAGLE HAS WINGS

Following the success of the *Daedalus* final report and *High Road to the Moon*, the Society is now publishing a third book.

An exciting progression of space achievements in the years following the Second World War led to Man's first landing on the Moon in 1969. Rockets for probing the upper atmosphere evolved into the space launchers we know today. Vanguard, Explorer, Atlas, Titan, Mercury, Gemini, Apollo – a succession of names to conjure up memories of the 50's and 60's when man was taking his first tentative steps into outer space.

***"The Eagle Has Wings"* tells the story of the major US Space projects from 1945 to the watershed year of 1975, when the Apollo missions came to an end and the first wave of interplanetary exploration gave way to the more sophisticated probes of today. Written by *Spaceflight* managing editor Andrew Wilson, it is packed with information and photographs. It runs to no less than 144 large-format pages and can be obtained for the low price of £7 ($16.00) post free.**

The book is available now. Be sure of your copy by sending for it now, to the British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

SMALL IS BEAUTIFUL

THE SHUTTLE OMS ENGINES

At launch, the Space Shuttle is powered by its Main Engines assisted by a pair of Solid Rocket Boosters, writes Petter Hesselberg. But it is the Orbital Maneuvering System engines that finally push the spacecraft into orbit after the more powerful main units have shut down. These OMS engines are housed at the rear of the Orbiter, together with a whole collection of small thrusters for fine control. They also see service for large orbit changes and slow the craft down to begin reentry.

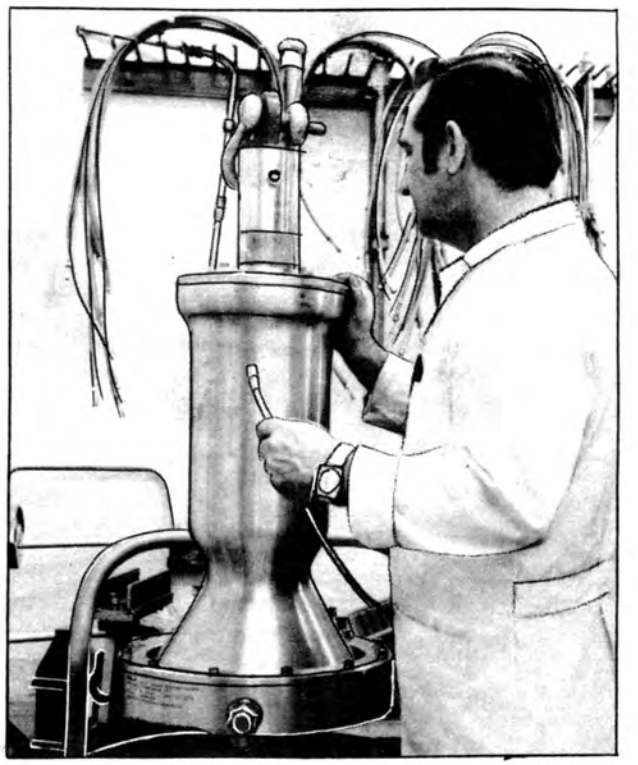
The two OMS engines are made by the Aerojet Liquid Rocket Company, and, like most of the Shuttle's subsystems, are designed for reuse at least 100 times. They are fired several times each mission, being designed to withstand up to 1,000 burns and a total firing time of about 15 hours.

Each engine is quite small, about 193 cm long and 115 cm in diameter at the base of the nozzle extension. Its weight is also surprisingly low, only 135 kg. Maximum thrust is approximately 27,270 N (6,000 lbf), which allows a total velocity change of 300 m/s during a normal mission. Altogether, the pair have 10,860 kg of propellant available, housed in the two pods. The nitrogen tetroxide and monomethylhydrazine combination is hypergolic; that is to say, it ignites on contact (that's why one of the first jobs after landing is the removal of excess propellant).

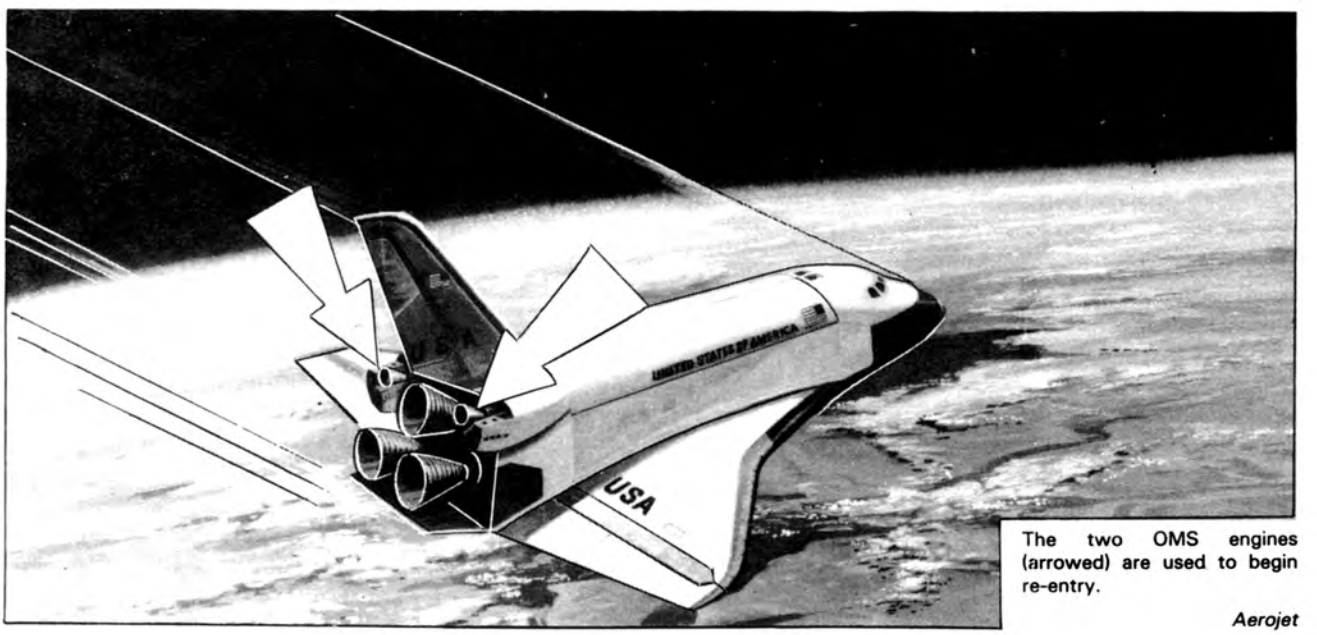
To control thrust direction, the engines are gimbal-mounted with electro-mechanical actuators attached to the forward end of the combustion chambers to allow a movement of $\pm 8°$.

The propellants are also used to cool the combustion chamber: before entering, they pass around it through 120 coolant lines.

Due to its simplicity the engine is very reliable. The propellants are pressure fed to the engine by helium, with the flow controlled by valves. These valves are activated by high-pressure nitrogen, and close automatically when power to them switches off. The number of engine restarts on any one mission depends upon the nitrogen pressure; since the de-orbit burn is essential, sufficient pressure for one start is stored in an accumulator. This ensures a safe return to Earth, even if the nitrogen tanks lose their pressure.



The combustion chamber and throat of an OMS engine are remarkably small. In use, they will be surrounded by a mass of tubes, wires and other equipment.



The two OMS engines (arrowed) are used to begin re-entry.

Aerojet

SEEING IS BELIEVING

Or: How the Atlas Rocket Hit Back

The Atlas launcher and the Centaur upper stage are unique in deriving most of their structural strength from their inflated thin stainless steel propellant tanks. If the pressure is lost, the tanks sag like punctured balloons.

The idea has worked brilliantly since the first Atlas launch in 1957. But the concept was not without its opponents, especially when Centaur came to be built shortly after. BIS Fellow Deane Davis, closely involved with Centaur at General Dynamics/Convair for many years, describes one illuminating – and amusing — incident from the early 1960's.

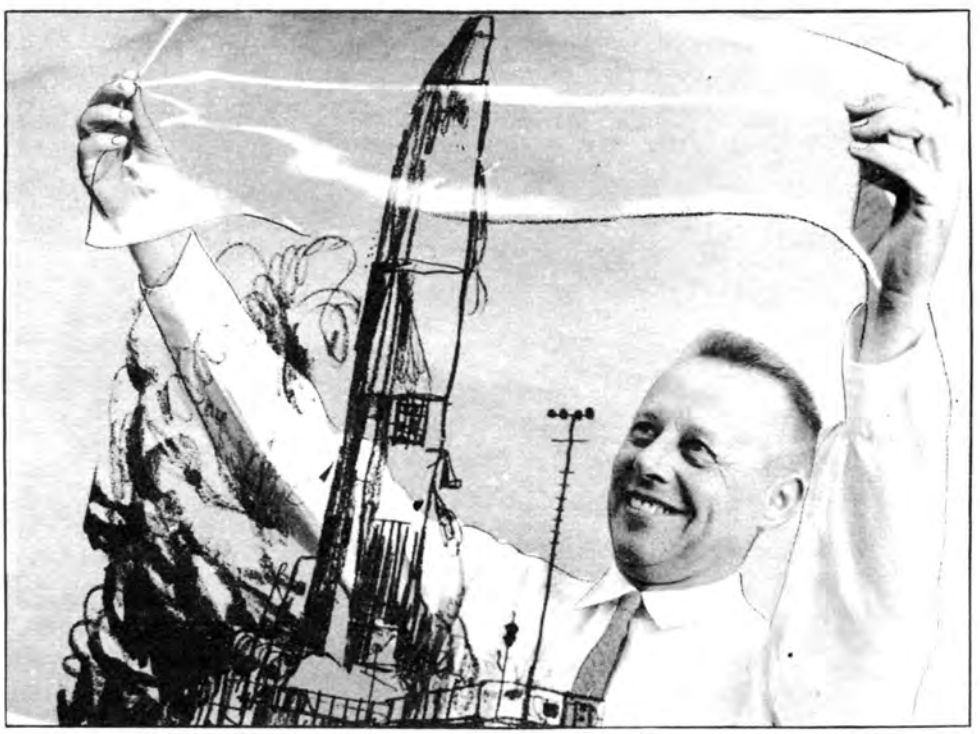
Introduction

Karel "Charlie" Bossart, the "Father of the Atlas" – and its inventor – was a shy, quiet, lovable self-effacing man who was quite tolerant of the criticisms pointed at the innovations inherent in the Atlas design, particularly his pride and joy: its balloon structure. After all, he pointed out after the first Atlas looped-the-loop under power without breaking up, it hangs together pretty well. But there was one group that made him uncomfortable: von Braun's coterie. Perhaps it was because they were Germans – and he was a Belgian (he used to refer to his fellow worker, Krafft Ehricke. as being "different"). More likely, it was the vast difference in basic structural philosophy between himself and the Huntsville group; his light egg-shell concept of structure *vs* the German's traditional "bridge design", as he called it.

The situation began to heat up when the Centaur Program was transferred to von Braun in the early 1960's and the Convair Astronautics plant in San Diego became deluged with Huntsville personnel attempting to understand their new creature. We in the Centaur Program usually found it expedient to shield Charlie from unnecessary encounters with the rank and file of Huntsville troops. But with the announcement of a get-acquainted tour by von Braun and his senior staff we resigned ourselves to the inevitable. We did, however, accost Charlie to implore him to not be drawn into any arguments; they were, we pointed out, our new bosses. Charlie, always accommodating, vowed he would wear his shiny new halo.

And he did. Visiting day arrived and von Braun and his contingent were whisked through a rapid tour of the plant, test laboratories and the Sycamore Canyon hot-firing test base nearby. Charlie was in the forefront of these festivities letting Krafft and I handle Centaur-related questions (since it was our machine) and even shunted most of the Atlas matters to me. The trouble began after lunch.

The afternoon session was to be devoted to detailed briefings and presentations on the various Centaur and Atlas systems. Charlie, at his place at the long table across from von Braun, became, as usual, bored and restless as the familiar information poured forth. The effect was the same on Willie Mrazek, von Braun's Structural Section Chief, who was seated to Charlie's right. I watched with misgivings as a spirited whispered conversation, accompanied by arm wavings, began to develop between the two. From time to time their



Karel "Charlie" Bossart, designer of the Atlas. A picture of innocence, but . . .

Convair (courtesy of Mitchell R. Sharpe)

discussion rose above the whispered stage and broke into the flow of the presentation. At such times Mrazek would be silenced by an annoyed glance from von Braun. I knew what they were discussing: Charlie was trying to explain the balloon structure to a disbelieving Mrazek and from experience I knew that the only solution was to get those two gentlemen separated from the briefings so they could have at it. Thoughts became action when Jim Dempsey, Astronautic's President, waved to me to get the two of them out of there. I motioned to Hans Hueter to meet me outside the hall.

Hans Hueter was an extremely brave man with a seemingly impossible task. Recently appointed as Centaur Program Director by von Braun, it was his job somehow to merge two diametrically opposed design and administrative concepts into a successful whole. To the Huntsville people the methods and philosophies of the Atlas and Centaur were as mysterious as the dark side of the Moon. On the Astronautics side, still riding the crest of their brilliant success with the Atlas, and with no reason to believe that the Centaur would prove to be any different, the new Centaur people resented what they felt was undue interference in their established manner of creating, producing and operating their product. After all, they said repeatedly, the Atlas and Centaur were their inventions. Historically, this meeting was at the beginning of what proved to be a very unhappy time for Centaur, a stormy period which culminated in the transfer of the project to the Lewis Research Center. Through it all Hans Hueter remained a steady rock in troubled waters. It can be said unequivocally that he was one of the very few Germans (of that time) respected and loved by his unruly wards at Astronautics. The relationship between Hueter, Ehricke and I was one of a close personal friendship. There were very few secrets between us.

In the hall I explained the situation to Hueter. He agreed and went back inside and whispered a few words to von Braun who looked at Mrazek and pointed toward the door. Mrazek followed Hueter and we were presently joined by Charlie Bossart. Charlie already knew what he wanted to do.

"Is there a test tank on standby?" he asked me.

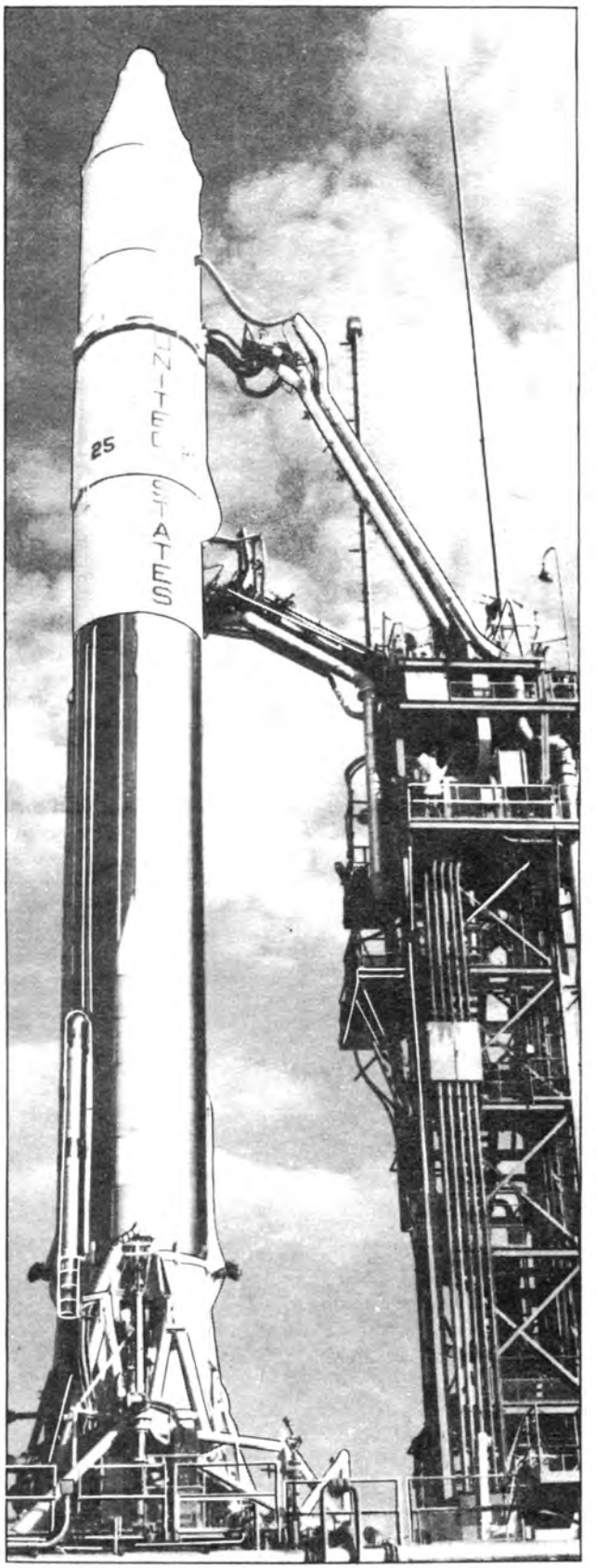
I nodded. Knowing what was coming I was wishing fervently that there wasn't.

"Can you get my hammer?"

Wincing, I nodded again. From experience I knew that if I didn't produce Charlie's "hammer" he would obtain one not quite so suitable from any passing workman. At Astronautics, Charlie was adored as "one of the boys".

In response to Hueter's questioning look I took him aside to explain what was about to happen. As I drew away I heard Charlie ask Mrazek if he could belt one of *his* rockets with a sledge hammer. Mrazek was looking at Bossart as if he had suddenly lost his senses.

We had discovered long ago, I told Hueter, that an inflated Atlas tank was practically indestructable when hit by anything other than a very sharp object. Like a football, it simply sprang back into its original shape. We had discovered this phenomena long ago; in fact, we had created a game around it. Unlike that football which transforms the energy of the blow into flight, our tanks were restrained by their handling fixtures and, unable to move, they sent the energy of the blow



The Atlas booster and Centaur upper stage, seen here together, derive their structural strength from internal pressure. Atlas Centaur was responsible for launching the first probes to Jupiter and Saturn, the Surveyor lunar soft-landers and a whole host of Intelsat communications satellites. Centaur will see service in a modified form in a few years as part of the Shuttle.

Von Braun and associates visit Convair in 1961. Deane Davis talks to Von Braun in the main group; at far left is Krafft Ehricke, to his right is Hans Hueter; second from far right is Karel Bossart.

Courtesy of Deane Davis

straight back into the object that struck them. The game consisted of seeing how far the hammer would sail after the blow – if the striker had successfully gotten out its way. We had evolved rigorous rules as to the pressure in the tank (usually "standby pressure", of 8 to 10 p.s.i.) the thickness of the skin and various other factors. Severe damage to some of the contestants and knicking of some tanks by unapproved "hammers" caused the game to be banned. The approved "hammer" was really a fibreglass mallet weighted with lead to give a head-weight of 7 lb (3 kg). Over this mallet-shaped head was molded a rubber cover; the handle was precisely 2 ft (60 cm) long. Hueter told me that, knowing Willie as he did, we might have a go at the tank. I could see that he didn't really believe me either. I phoned Frank Kemper, our Factory Manager, to set up the demonstration. Kemper, one of the originators of the game, was delighted.

Proof of the Pudding

In the factory yard a static test stub tank sat shining in the Sun on its handling fixture. It represented, Frank told me, the lower part of the liquid oxygen tank (which meant that its skins were about 0.03 inch thick) and stood at a pressure of 8 p.s.i. A healthy specimen. Mrazek looked it over carefully. He noted dust and bird-droppings on it.

"You should keep it covered," he told Bossart.

"Why?" answered Charlie, "it's stainless steel, isn't it?"

Mrazek shook his head.

"What's inside it?" he asked.

"Nitrogen," said Charlie happily.

"I mean ribs, structure."

"Nitrogen," Charlie repeated.

Mrazek walked around the tank shaking his head. He tentatively pushed on its gleaming side with his thumb. It yielded slightly but was unexpectedly firm.

"What happens when the nitrogen leaks out?"

"It doesn't," said Charlie firmly. "Only when we put in the helium. And, remember, flight pressure is about four times the presssure you are seeing here."

Willie Mrazek digested this. It was hard going.

"Frank," I said, trying to make the encounter as short as possible, "do you have Charlie's hammer?"

"Right here."

Bossart handed the hammer to Mrazek. Willie hefted it, surprised at its weight.

"Now, my friend," said Charlie, pointing to a spot on the swelling side of the tank, "whack it!"

Mrazek lifted the hammer and gingerly tapped the tank with it. He immediately inspected it to see the dent. The shiny skin gleamed back at him unblemished. A flush of red crept around his collar.

"No, Willie," said Charlie disgustedly, "belt it!"

Mrazek took off his jacket, hefted the mallet and tapped at the tank smartly. The hammer bounced back and Willie almost lost his grip. He looked again but was unable to find the spot he had struck.

Hans Hueter was looking on as amazed as Mrazek. "Are you guys crazy?" he asked me in an undertone.

"Willie," said Charlie, enjoying himself immensely, "stop fiddling around. Hit the damned thing!"

Mrazek, red in the face, strode up to the tank and gave it a smart crack. The mallet flew out of his hand, knocking off his glasses as it went by his face. Kemper recovered them and Willie inspected the surface to find the dent that was certain to be there. Aside from a black smear left by the mallet's rubber covering the surface was unmarred. Snorting and muttering dire things under his breath in German, Mrazek searched around the tank fixture for the hammer. He had done very well, it was some 15 ft (4.6 m) away. It was clear that I'd receive no help from Charlie or Kemper; they were standing there grinning like a pair of baboons. Hueter was helping Mrazek heft the hammer and settle on the next point of attack.

"Hans," I called, making a great show of examining my watch, "isn't it time you got Willie back to the meeting?"

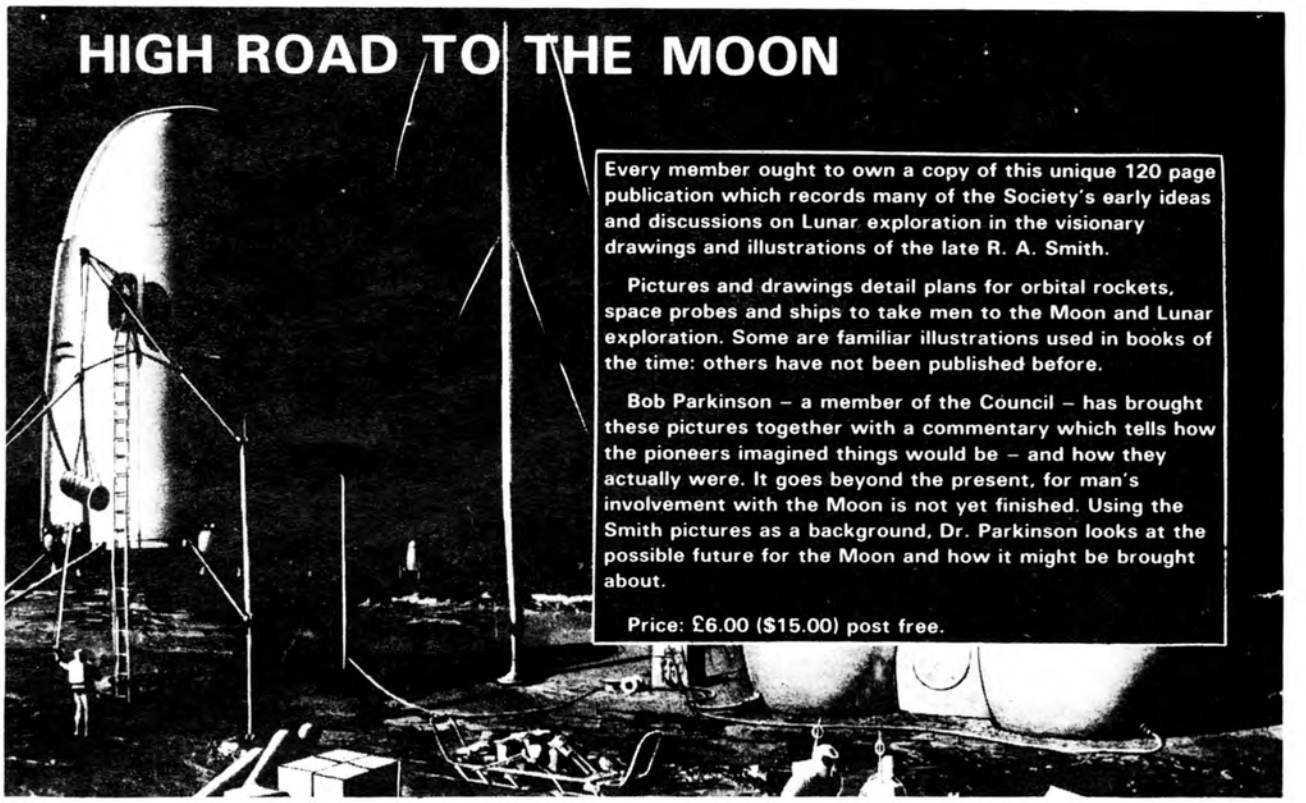
While Mrazek's back was turned I gave Hans a frantic across-the-throat sign. Thankfully, he read the urgency in my gesture, and, retrieving Willie's coat, led a protesting combatant away, shepherded by Frank Kemper. I turned to Bossart.

"Boss,' I said, "what got into you? You know as well as I do that he could have killed himself!"

Unperturbed, Charlie Bossart looked me straight in the eye. He shrugged a Bossart shrug.

"I was playing the odds, that's all." The familiar impishness was on his face. "I figured that if it hit him in the head, he wouldn't know the difference!'

And he strolled off whistling.

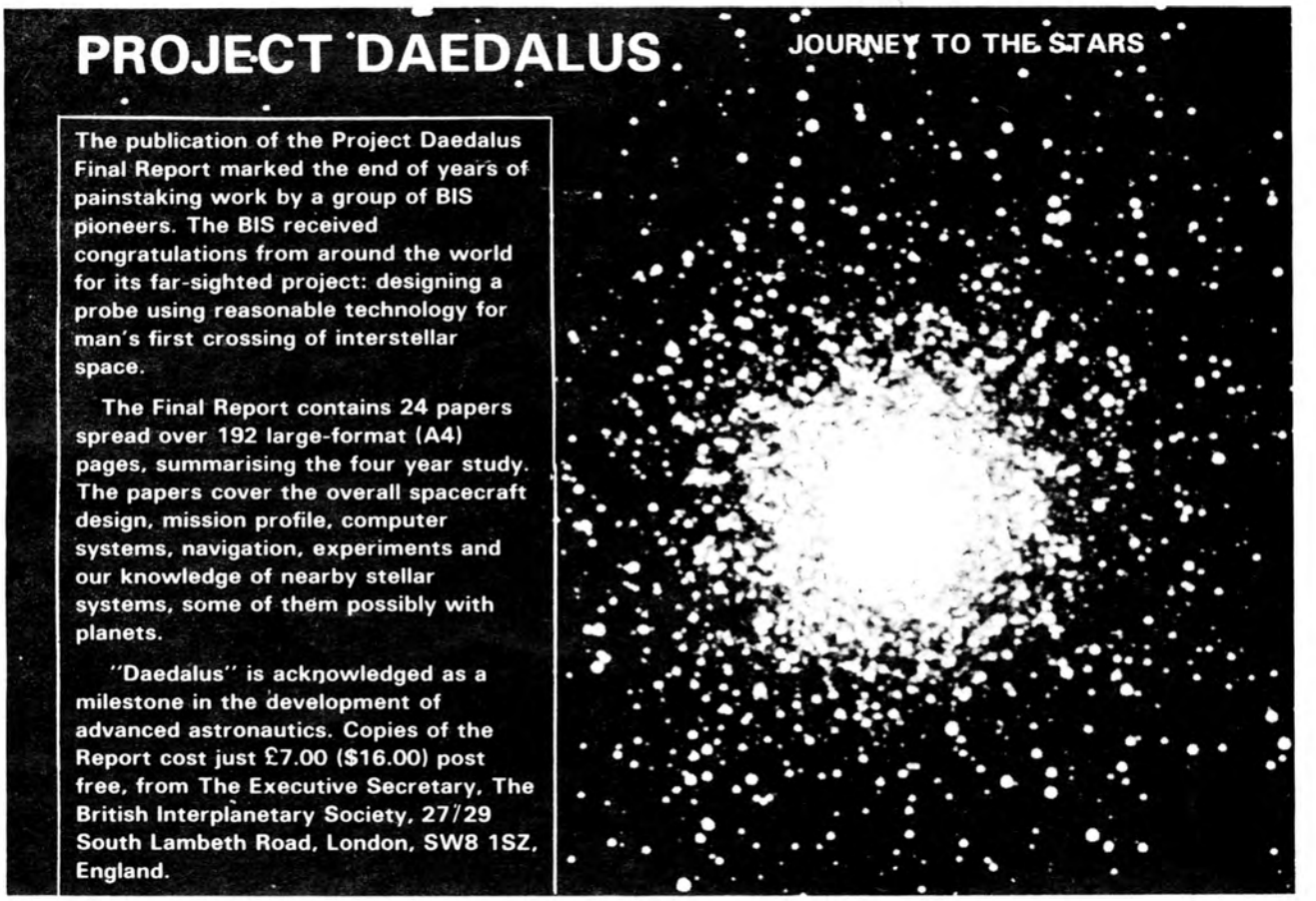


Every member ought to own a copy of this unique 120 page publication which records many of the Society's early ideas and discussions on Lunar exploration in the visionary drawings and illustrations of the late R. A. Smith.

Pictures and drawings detail plans for orbital rockets, space probes and ships to take men to the Moon and Lunar exploration. Some are familiar illustrations used in books of the time: others have not been published before.

Bob Parkinson – a member of the Council – has brought these pictures together with a commentary which tells how the pioneers imagined things would be – and how they actually were. It goes beyond the present, for man's involvement with the Moon is not yet finished. Using the Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.

Price: £6.00 ($15.00) post free.



The publication of the Project Daedalus Final Report marked the end of years of painstaking work by a group of BIS pioneers. The BIS received congratulations from around the world for its far-sighted project: designing a probe using reasonable technology for man's first crossing of interstellar space.

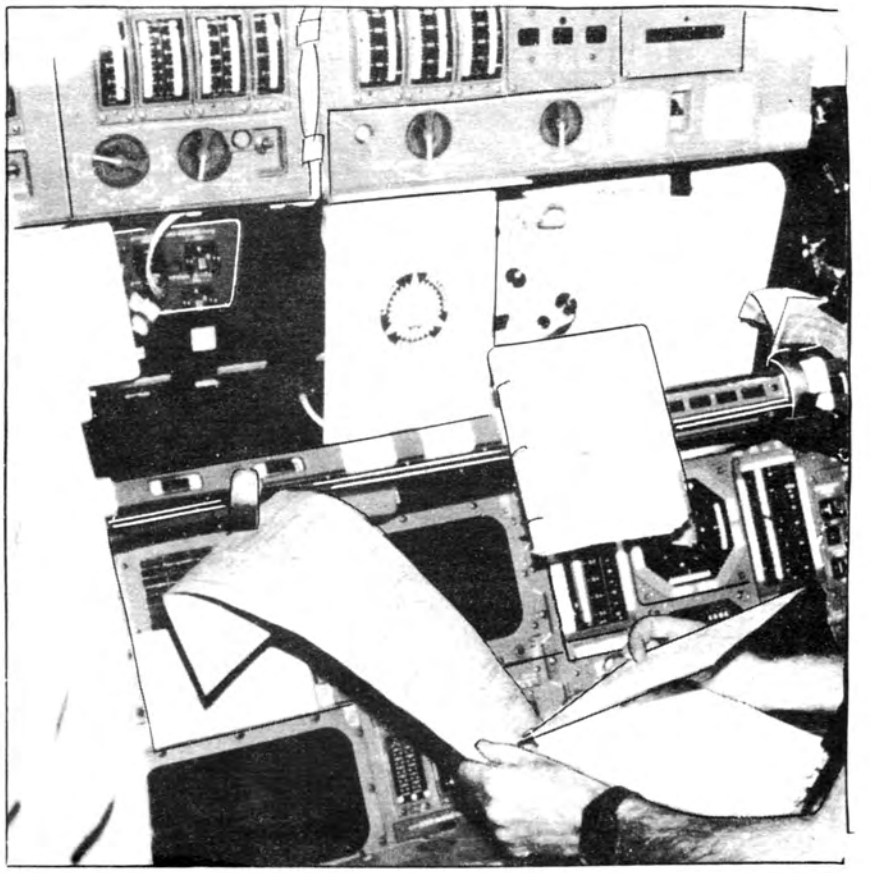
The Final Report contains 24 papers spread over 192 large-format (A4) pages, summarising the four year study. The papers cover the overall spacecraft design, mission profile, computer systems, navigation, experiments and our knowledge of nearby stellar systems, some of them possibly with planets.

"Daedalus" is acknowledged as a milestone in the development of advanced astronautics. Copies of the Report cost just £7.00 ($16.00) post free, from The Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ, England.

SHUTTLE RESUMÉ

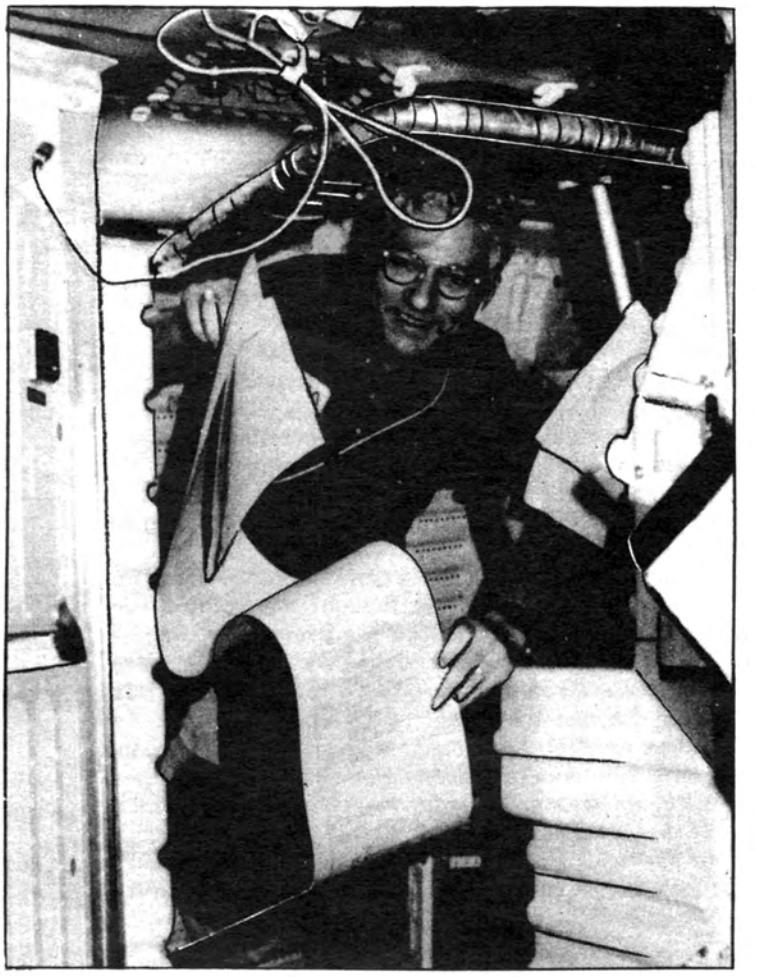
Now that the number of Shuttle missions is gradually creeping towards double figures (it should get there in December), the details of past flights are beginning to dim a little in the memory. Was it Jack Lousma who commanded STS-3, or Tom Mattingly? The problem will get worse as the crews fly five, six or seven people at a time. Here's a selection of pictures previously unpublished in *Spaceflight* showing a few of the astronauts. Before peeking at the captions, why not try seeing how many of them you can name? The summary so far is:

STS-1	Young & Crippen
STS-2	Engle & Truly
STS-3	Lousma & Fullerton
STS-4	Mattingly & Hartsfield
STS-5	Brand, Overmyer, Allen & Lenoir
STS-6	Weitz, Bobko, Peterson & Musgrave.



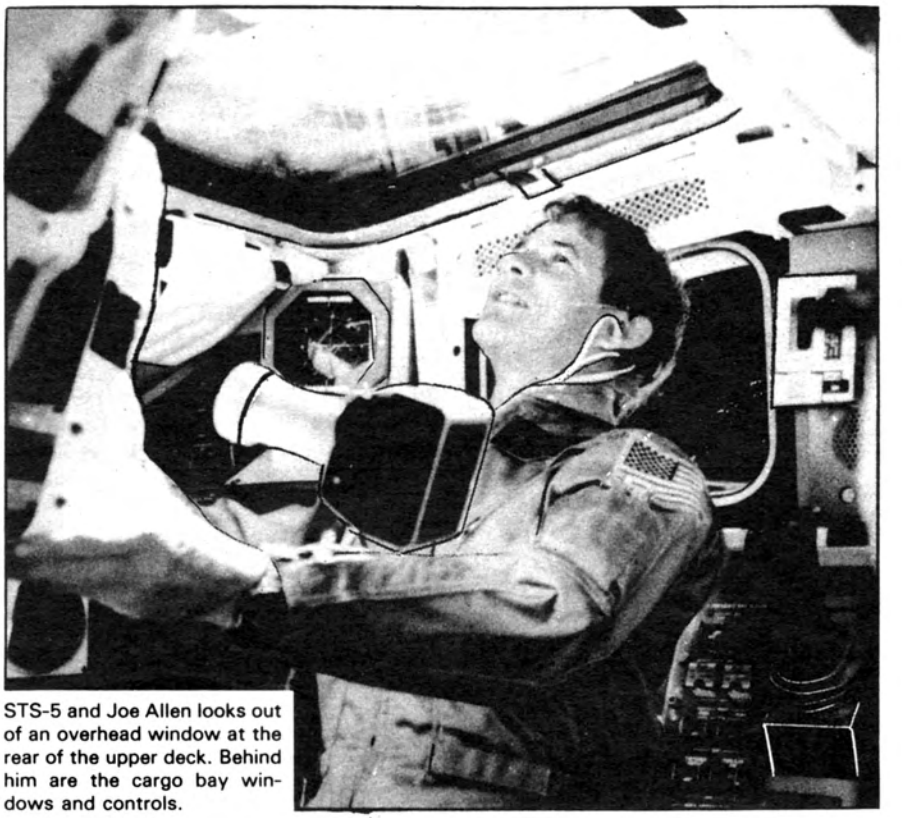
Gordon Fullerton (STS-3) in his pilot's seat studies teleprinter messages from Houston — intended just for the test flights. *Right:* Henry Hartsfield (STS-4) has problems keeping his

Bill Lenoir on the receiving end of NASA discipline? No, Joe Allen is taping him to the floor before beginning biomedical tests during STS-5. *Right:* Bill Lenoir gives Bob Overmyer a trim during STS-5. Behind them are the stowage lockers of the mid-deck area.



ejector seats are no longer used aboad the Shuttle; they were own teleprinter paper under control.

All pictures NASA



STS-5 and Joe Allen looks out of an overhead window at the rear of the upper deck. Behind him are the cargo bay windows and controls.

T 22

ANTIMATTER & DISTANT SPACE FLIGHT*

By Dr. George Mueller

Introduction

In the four years since the BIS issued its pathfinding Daedalus study there have been enormous strides made in antimatter development, many of them reported in the Journal of the BIS. In fact, the September 1982 issue was devoted to the latest anti-matter research. Yet at the pace this research is progressing, even these recent papers will soon be out of date.

I believe it is time to stand back and assess the direction of these developments. They are far more than just interesting scientific findings. Since I believe that they hold great promise for interstellar travel, I would suggest that it is time to capitalise on the pioneering work done under the aegis of the BIS. I do not think it is too soon to seriously start heading for the stars.

This is contrary to today's conventional wisdom, but 30 years ago few people thought man would ever travel in space. Yet only ten years later, Yuri Gagarin made that historic flight, and man was indeed in space. Less than 20 years later, Neil Armstrong and Buzz Aldrin stepped onto the lunar surface.

Just as there are dangers in speculating on the ultimate potential of research still in its infant stages, there are dangers in applying conventional wisdom when evaluating new and speculative ideas. My favourite example of this was a commission report which concluded its evaluations of a proposal with the following words:

"The committee judged the promises and offers of this mission to be impossible, vain, and worthy of rejection; that it was not proper to favour an affair that rested on such weak foundations and which appeared uncertain and impossible to any educated person, however little learning he might have."

This particular report was prepared by the Talavera Commission in Spain, considering a proposal in 1491 by Christopher Columbus who wanted some financing for a speculative exploration he had in mind.

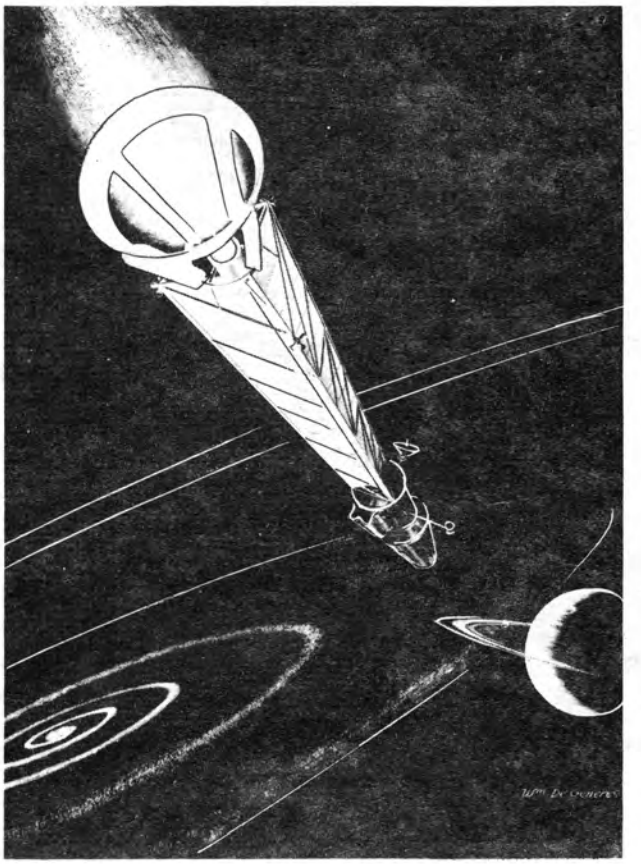
Arthur Clarke's thesis is demonstrably true. Technological forecasts are over-optimistic in the short run, but over-pessimistic in the long run. It would seem that the human mind tends to extrapolate in a linear manner, whereas progress is exponential. The exponential curve rises slowly at first, and then climbs rapidly, until eventually it cuts across the straight line slope and goes soaring beyond it.

All of this is a useful preamble when one is dealing with the subject of interstellar travel. No, we are not on the threshold of interstellar travel, at least not in the sense that we are on the threshold of a manned mission of Mars. For projects such as this, we not only know we can do them, we know *how* we can do them.

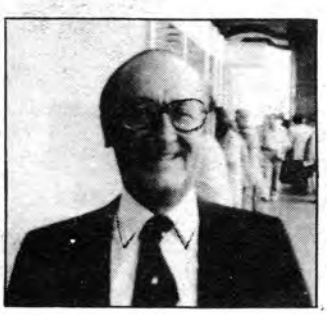
The "how" of interstellar travel is a little less clear at the present time, but there are some new approaches to this speculative subject. Until Einstein was so churlish as to place a speed limit on space travel at 300,000 km/s, zipping from star to star didn't seem to be much of a problem. As early as 1643, Kepler concluded in his *Somnium* that as the voyage progressed, it would no longer be necessary to use any force for propulsion.

So early space travel speculators concentrated on a problem they knew existed: gravity. They "developed" space guns powered by gunpowder, giant flywheels, anti-gravity devices such as the H.G. Wells "Cavorite," and, of course, rockets. In 1865, Jules Verne postulated a 300 m long spacecraft with shock absorbers, air conditioning, and padded walls with windows. He even launched his vehicle from Florida, not far from Cape Canaveral.

Einstein's speed limit created some problems for interstellar spaceship inventors. Even if a space vehicle

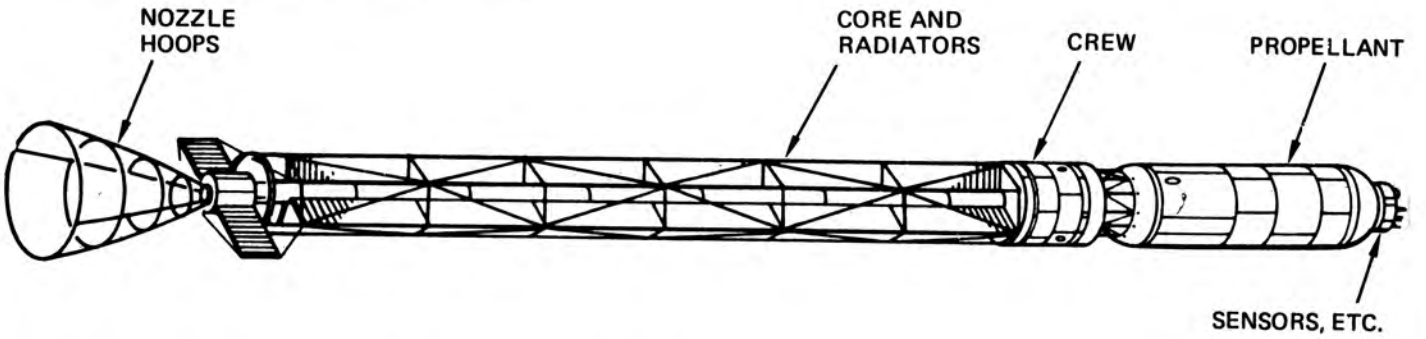


A deep space vehicle using antimatter propulsion. From a painting by Wm. De Generes.



* Adapted from Dr. Mueller's presentation to Space '82, Brighton, November 1982.

Antimatter & Distant Space Flight/contd.



maintained its Earth escape velocity of 11.2 km/s, it would take over 100,000 years to reach our nearest star. Since that's a fairly long trip for even an unmanned vehicle, the concept of manned interstellar flight has remained pretty much in the realm of science fiction. There, such concepts as time-warps and hyper-space drives solved the problem for science fiction writers but were not taken seriously by serious scientists.

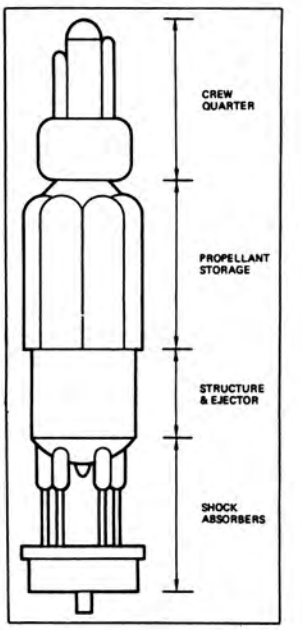
But a new era was ushered in less than 40 years ago. The potential of high energy physics was quite dramatically demonstrated to the world at Hiroshima and Nagasaki in 1945. While many reflected only on the destructive power of fission energy, others immediately saw its potential as a power source. As early as 1946, Ulam proposed using the atom bomb as a means of generating propulsion. Within a decade, he and Everett had designed a spacecraft propelled by one kiloton bombs ejected every second and ignited about 50 m behind the vehicle [1].

By 1968, we were seeing designs of spacecraft using external nuclear pulse rockets, the most notable of which was Orion. Taking a look at Orion, we see that the base vehicle consisted of the crew accommodation, a propellant storage area, the ejector and shock absorbers. The lower end of the shock absorbers was a pusher plate which reflected the gases from the nuclear explosions. Even with the limitation imposed by the ablation rate of the plate surface materials, the Orion design provided specific impulses on the order of 5,000 seconds.

Also in 1968, Dyson proposed using nuclear fusion bombs because of their higher energy content. By the early 1970's, scientists were considering laser ignition of low-yield pellets. The Daedalus vehicles [1,2] used relativistic electron beams to ignite pellets of deuterium and helium-3. With a specific impulse of 10^6 seconds and an acceleration from 0.1 to 1.0 m/s^2, Daedalus promised a three-order-of-magnitude improvement over chemical rockets. And it was calculated that the flyby of Barnard's Star, 6.1 light years away, could be accomplished in 45 years flight time. The two-stage vehicle could bring a 500 tonne payload to a final speed of just over 12 per cent of the speed of light.

Enter Antimatter

When one begins talking seriously about percentages of the speed of light, interstellar travel suddenly emerges from the realms of science fiction. Space scientists began to follow the development of fusion energy with considerably more interest. With this growing realisation of the propulsion potential of fusion energy, the serious world technical literature on interstellar flight had grown to nearly 3,000 references by 1980 [3].



Above: possible appearance of an antimatter spaceship. *Left:* the Orion vehicle of the 1960's was based on external nuclear pulse rockets, with pusher plates absorbing the energy from nuclear explosions [9].

Now, there appear to be developments in another area of sub-atomic physics that offer even greater promise for interstellar flight than does fusion power: antimatter.

There is little question as to the potential of antimatter. The total annihilation and its conversion to energy which results from the interaction of matter and antimatter, is the most intensive source of energy theoretically possible. It releases between 100 and 1000 times more energy per unit mass than a typical nuclear fusion reaction. Effective harnessing of this enormous potential may open the doorway to interstellar flight (among other new capabilities) [4].

Science fiction addicts are undoubtedly aware that antimatter propulsion has long been a popular device in that genre. I am not predicting that an antimatter space drive will propel us to Alpha Centauri in the next 20 years. But I *am* saying that the science of antimatter has advanced to the stage that it merits serious consideration indeed. Largely from work performed in the past five years, antimatter is now routinely produced, stored, and *used* in experimental facilities. That is fact, not fiction.

Here is a brief survey of what's been happening in antimatter research and development.

The notion is not new that each class of fundamental

particles in nature is in symmetry with a mirror-imaged class of antiparticles. Predictions of this arose out of theoretical work early this century and were first confirmed with the discovery in 1932 of the positively charged electron, called the positron. Since then, advances in linear accelerator technology have led to production of heavier antiparticles such as antiprotons, and antineutrons. Some think that antimatter exists naturally in the cosmos, but the amount and its ultimate accessibility are debatable, so we have to generate it in our own laboratories.

The technology of producing antimatter with particle beams is under development at numerous high energy particle laboratories around the world. The European Centre for Nuclear Research (CERN) includes a 7 km circumference synchrotron straddling the French-Swiss frontier near Geneva. There, collections of up to a billion* antiprotons are produced, accumulated, and held in magnetic "racetrack" storage rings for periods up to four days. Extension of this capacity is anticipated in the United States by the mid-1980's when the Fermilab Tevatron is brought into operation.

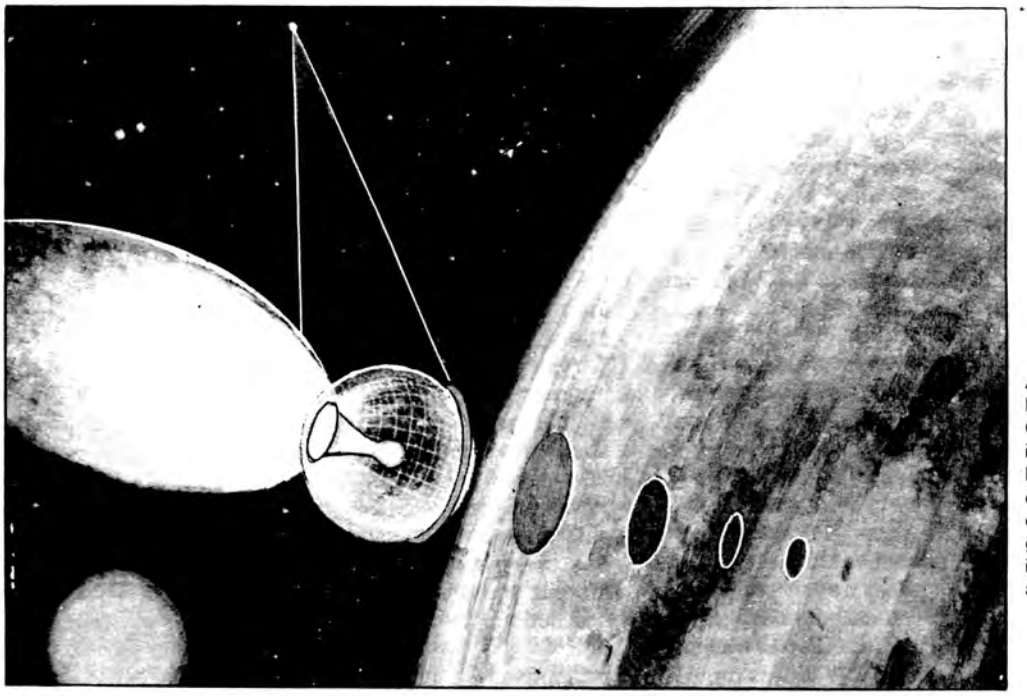
CERN's method of making antiprotons is to send a high energy beam of protons into a dense tungsten target. When the protons strike the heavy tungsten nuclei, their relativistic kinetic energy is converted into a spray of particles, some of which are antiprotons. These are separated magnetically and are funnelled into a particle decelerator which slows them to lower velocities. Then they are captured and "cooled" in an antiproton beam magnetic storage ring and cooler. At CERN, the original proton beam is generated by a 26GeV accelerator. The resulting antiprotons are captured in the large 7 km synchrotron which has been adapted successfully to serve as a counter-circulating proton-antiproton storage ring. At Fermilab, antiproton production will be increased and the original proton energy raised from 26 GeV to 80 GeV.

The cooling and storage of antimatter present technical challenges, of course, but these challenges are being met and overcome. After being separated from other debris and being decelerated, the produced antiprotons have a wide range of energies, which must be narrowed if we hope to control or store them in condensed form. At CERN, an electromagnetic stochastic process, and at Fermilab, a pilot electron beam method, have been demonstrated successfully for accomplishing this smoothing out and cooling process. Improved electron cooling techniques are also under development in the USSR [5].

Further deceleration and cooling could produce a slow-moving beam of antiprotons, which could be combined with a similar beam of positrons to result in a beam of anti-hydrogen atoms. Because anti-hydrogen is diamagnetic, it can be directed and trapped using magnetic fields in a cryogenically cooled vacuum chamber and condensed into a small ball of liquid or frozen anti-hydrogen. Since it is not possible to store antimatter mixed with matter in gaseous, liquid or solid form, and probably not possible to store it in contact with matter even at an interface, only magnetic, electric, or laser levitation confinement appear as possible storage methods for antimatter. Variations of each of these methods have been demonstrated with normal matter and should work equally well on antimatter.

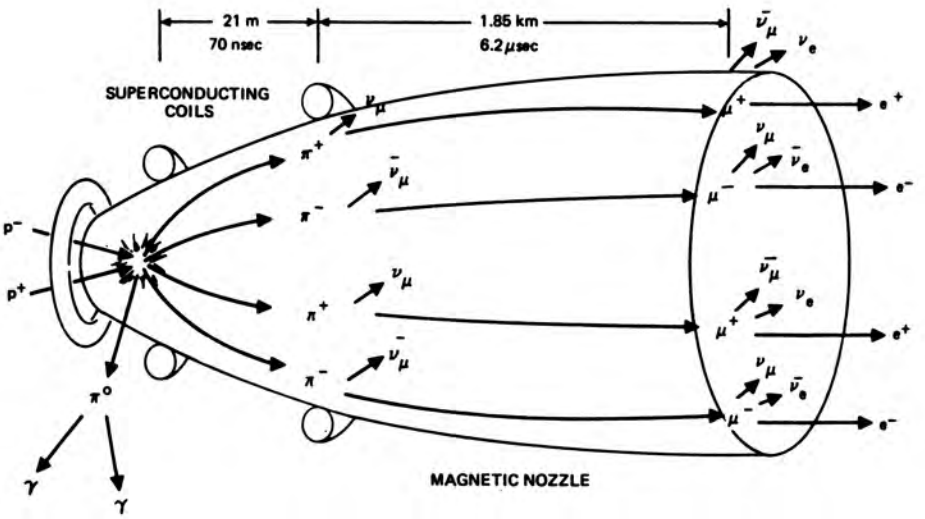
The production and control of antimatter on practical engineering scales is still well in the future. With present equipment, we can hope to produce, capture and store only about one antiproton for each million normal protons we start with in the initial accelerator beam. Accumulation of a *billion* antiprotons requires a proton pulse to the tungsten target every 2.4 seconds for 40 hours, and the resultant annihilation potential is only about 300 joules. That's about the equivalent of the

* 1 billion = 10^{12}



A concept from 1976 by Dr. R. L. Forward: a "Golden Globe" small interstellar probe in orbit around a planet of Proxima Centaur. The 100 m diameter mesh carries arrays of sensors and transmitters to gather information and send it back to Earth, 4.3 light years away.

Hughes Research Labs.



Thrust from antimatter annihilation. The protons (p) interact to produce pions (π) channelled by the magnetic field. The pions decay, emitting neutrinos (ν), into muons (μ), which then decay into electrons (e).

"bang" from a cap pistol. This might seem to make the whole thing seem trivial, except that this 300 joules of potential is packaged in only two-billionths of a gramme of antimatter.

So we have a long way to go, but the potential is there and we are beginning to find clues on how it may be harnessed. Our present machines are designed only for scientific research, not for antimatter production and operations. As we focus on ways of increasing proton production in our accelerators, improving anti-proton yields and enhancing capture and storage techniques, we can expect rapid strides in antimatter production and storage capability. Studies of such prospects are already getting underway, sponsored by NASA and the US Air Force.

Antimatter Propulsion

Now, what about propulsion systems based on antimatter energy? The first investigations of such systems were carried out by Sänger in 1953, with emphasis on the photon (light) rocket. The photons could be created by combining equal numbers of electrons and positrons, but it was difficult to devise methods for directing the resulting gamma rays into a collimated beam. Sänger gave considerable thought to development of electron gas mirrors for these gamma rays, while subsequent work has centred around magnetic nozzles on the order of 2 km in length to direct the annihilation debris into a reactive thrust beam.

A recent study [6] shows that if proton-antiproton annihilation took place in a magnetic field reaction chamber, the interaction of the charged pions with the magnetic field over a 21 m path would convert the onmi-directional antimatter-matter explosions into uni-directional thrust. After 70 nanoseconds, the charged pions decay into charged muons which live 6.2 microseconds, long enough to travel 1.85 km.

Another study [7] concludes that if the magnetic nozzle can direct the charged pions into uni-directional thrust before they decay, the maximum efficiency of the rocket is about 67 per cent. Directing the longer-lived muons would produce a 52 per cent maximum efficiency.

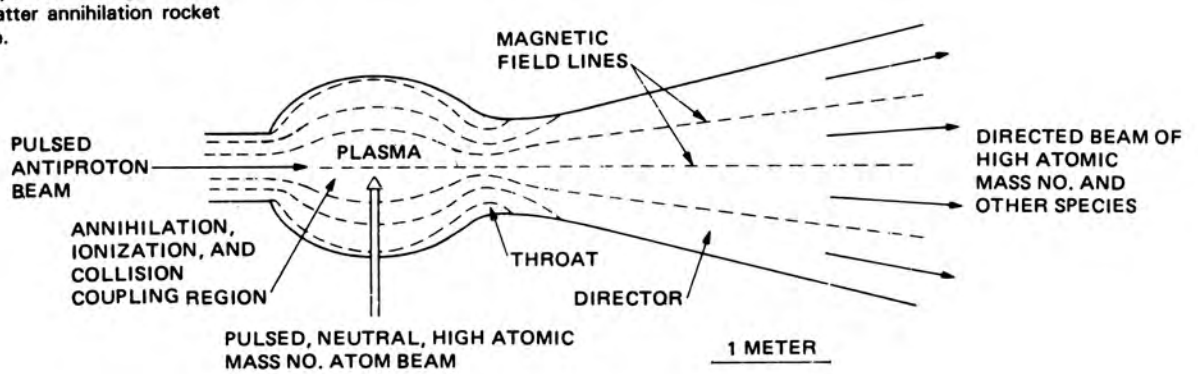
It has been determined more recently that the best way to use antimatter for propulsion is not to use equal amounts of matter and antimatter. Rather, smaller amounts of antimatter should be used to heat and accelerate a much larger amount of propellant, such as liquid hydrogen, as a reaction fluid. This arrangement should produce specific impulses in the range of several thousand to several million seconds, depending on the ratio of antimatter to reaction fluid, and much higher thrust levels than are possible using total annihilation. The analysis reaches the interesting conclusion that, except for extreme relativistic spacecraft speeds (greater than half the speed of light), the reaction mass needed is always nearly four times the spacecraft payload mass, or an overall mass ratio of 5:1. The amount of antimatter needed for a given mission velocity gain is proportional to the mission payload and to the square of the ratio of that mission velocity gain to the velocity of light.

To give a simple example calculated by Dr. R. L. Forward, let us send a one ton payload on a one-way mission to Alpha Centauri, a modest 4.3 lightyears away. If we wanted to have that one ton payload rendezvous at Alpha Centauri in 25 years, we would need to launch a five ton second stage propelled by 20 tons of reaction mass and 180 kg of anti-hydrogen. The antimatter would accelerate the spacecraft up to two-tenths the speed of light in less than one year. After coasting at that speed for 21.5 years, the spacecraft would approach Alpha Centauri and the second stage would use its four tons of reaction mass and 36 kg of anti-hydrogen to bring the one ton payload to rest in the Alpha Centauri system.

From this simple example, we can see that modest interstellar missions and certainly more sophisticated, short-duration Solar System voyages, can be accomplished readily if antimatter can eventually be manufactured and handled in quantities of a few hundred kilogrammes.

A variation on this approach [8], requiring less antimatter, is to transfer more of the exhaust energy to additional matter that would form part of the exhaust. In such a collision-coupling system, matter (in the form

Concept for a high thrust antimatter annihilation rocket engine.



of a gas) is introduced into the annihilation and/or exhaust region of the rocket engines. Collisions between the particles produced by annihilation and the gas atoms lead to a transferral of kinetic energy to the gas. In the process, the gas atoms become ionised; hence they can be directed rearward from the engine by a magnetic field. The result is an exhaust of nearly the same energy as with the gas, but with lower velocity and higher mass, momentum, and thrust.

It should be noted that in this particular design the amount of reaction mass is such that the exhaust velocity is lowered to only a very small fraction of the speed of light. Hence, this design would be incapable of practical interstellar missions, but would be very useful for rapid Solar System travel, having a thrust of about 57,000 kgf and specific impulse over 14,000 seconds. A practical interstellar engine would have to be designed more toward the total annihilation side of the spectrum.

Looking ahead to the 21st century, we can visualise different kinds of long-distance missions, both within the Solar System and beyond, which could turn out to be important. If experience serves as a guide, we can expect that differing missions will call for differing propulsion systems. Within the past two decades, a variety of advanced propulsion concepts have been suggested for future long voyages including laser and electron beam imploded micro-fusion pulsejets; laser driven lightsails; interstellar ramjets and their augmented versions using nuclear, laser, and antimatter augmentation; as well as antimatter rockets themselves. Because of its unmatched capacity to carry available energy in concentrated form, antimatter, either alone or in hybrid combinations with other energy sources, should be expected to figure prominently in space propulsion for the 21st century.

To produce the amounts of antimatter needed for interplanetary commerce and interstellar flight will require dedicated high current, high voltage particle accelerators. Accelerators with the necessary machine parameters to produce antimatter are under intensive development in both the United States and the Soviet Union for use in inertial fusion research and beam weapons development. As an example, in one design being studied, the particle accelerator will produce short bursts of protons with an energy of 10 GeV, more than enough to produce antiprotons, and a beam current of 10,000 amperes. The power in the beam of this accelerator would be 10^{14} watts, about 100 times the current power output of the entire world! Of course, since the machine will be operated in 10^{-8} second bursts, the average power is very much lower. As particle beam weapons are developed for space defence systems, the technology will come into being to make particle generators that have the capability to create significant amounts of antimatter, and there is no reason why such machines could not be engineered to run continuously as antimatter factories.

Other promising approaches have been identified for making antimatter, including production of proton-antiproton pairs with strong electric fields which can be generated by focused high intensity laser beams such as are under development for fusion and defence research.

It is worth noting that both fusion and antimatter research are dependent for their progress on present technologies such as plasmadynamics and high-energy particle and laser beam generation. This suggests that careful attention to the know-how being gained from the hundreds of millions of dollars invested each year in fusion research, with focused application, could result in important fallout benefits for antimatter technology.

Prospects are enhanced by the fact that all of the preliminary research can be done using normal hydrogen. Many viable research projects can be visualised for universities as well as government, focused on learning how best to slow and cool beams of protons, convert them to molecular hydrogen, put them in a storage bottle, then retrieve them and insert them in a reaction chamber without losing too many. What is learned in this way should be readily applicable to antiprotons as well.

The natural location for antimatter factories, in view of their large power requirements, is in space where continuous solar power is available. Using the solar flux at the Earth's distance from the Sun, a light collector about 300 km on a side could provide the power for a 10^{14} watt factory. If the efficiency of antiproton productions from each high energy proton in the initial beam could be made as high as 0.1 per cent, then this machine would produce 10^{20} antiprotons per second, or about 1 kg of antimatter per month.

An alternative, of course, would be the discovery of antimatter in the form of other bodies in space. The symmetry of our physical world, if nothing else, leads me to believe that there must be in the Universe an

equal mass of antimatter to that of matter. One can speculate that some of the larger craters we see on our own planet might be the result of small antimatter collisions. In any event, as the exploration of space continues, we may well find even in our Solar System, small quantities of antimatter amongst the debris from the primal explosion. If so, then we will have a ready-made source of energy for interstellar travel.

Antimatter represents the most concentrated energy storage mechanism we can yet imagine, and creative minds will certainly raise challenging proposals for its practical applications. As its technologies unfold, it will undoubtedly be used for generating everyday power, for planetary engineering and, we must expect, for defence systems. For these reason alone, the subject calls for increased attention.

But the brightest promise of antimatter is that it could be the most important key to our mastery of the farther reaches of space. Perhaps it will be a very long time before we can attain the rocket exhaust velocities or the antimatter production efficiencies needed for practical relativistic starflight. But even modest progress with antimatter propulsion would revolutionise transportation across the Solar System. Solar System travel could take a matter of days or weeks rather than months or years. And we have found no laws of physics which tell us we cannot go farther.

While it is certainly premature for me to present a detailed design of the eventual antimatter spacecraft, I have no qualms in extrapolating what it *might* look like. I'll concede that it doesn't bear much resemblance to the starship Enterprise in *Star Trek*. Much of its volume is devoted to the nozzle and the radiators for cooling superconducting nozzle coils.

Moreover, it must be noted that the design of the engine and the vehicle will depend greatly on the desired mission. For example, a fast-transit, high-thrust system for interplanetary flight would undoubtedly look very different, since it would require much greater reaction mass tankage. I am sure we will see many proposed designs as we go farther in the years ahead.

The question may be raised (and it surely will be) "Why go farther?" We're having difficulty convincing our modern Talavera Commissions of the importance of supporting even those near-time programmes of present space travel. Why should we even be considering programmes that may not reach their ultimate potential for a century?

I could address that question *ad infinitum*, but I doubt I could improve on the answer Norman Cousins gave three years ago when asked if space exploration was desirable. He said:

"It is not necessary to ask whether space exploration is desirable. It is necessary only to ask whether we believe in the need for human growth and evolution. The total commitment to the exploration of the Universe is the same as the commitment to human growth. If human evolution is conceived as the triumph of growth over inertia and decay, then our presence in space is not an unnatural or presumptuous exercise, but an acceptance of our role as custodians of our own evolution.

"We need not be confined to minor excitements or minor leaps. The great leaps are still the surest way to higher ground. Exactly what that higher ground has to offer is uncertain except for one presiding fact: it will point the way to yet higher stations. There is no guarantee that we will find any answers on these even more remote stations to any of the things we want to know. Yet we will discover something even more important. We will discover questions that we have never asked before. And the questions will be more rewarding than the answers, for the most devastating ignorance of all is not even to know what it is we do not know."

In the infant science of antimatter, the unknown dwarfs the known. But a beginning has been made. The British Interplanetary Society has led the way in interstellar studies in general and antimatter investigations in particular. Indeed, the Journal of the BIS is unquestionably the finest source of information for serious students of this exciting research.

Nor has the pioneering work of the BIS been in vain. It has sparked the imagination and interest of scientists worldwide. In fact, one of my first acts as the new president of the IAA will be to establish a standing committee on interstellar exploration. This committee will be devoted to studies dealing with both manned and unmanned exploration of interstellar space.

I believe that this will just be another stepping stone toward man's inevitable journey to the stars. I need not remind anyone here that in 1939 the BIS outlined the first articulated proposal to send men to the Moon and back. Most people outside the Society considered this to be science fiction, but 30 years later, we had accomplished that feat. Now, in 1982, the BIS is in a sense propelling us toward the stars. Will history repeat itself? Once again, the idea will be widely regarded as science fiction. But I am convinced that the more we learn, the more the question becomes not *whether* we can go to the stars, but *when*.

Acknowledgements

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9. Courtesy R. M. Sternbach.

MILESTONES

January 1982

19 Chimpanzee Ham, who made a Mercury suborbital flight in January 1961, dies at the South Carolina Zoo.

23 The main section of Kosmos 1402 burns up in the atmosphere over the Indian Ocean. The nuclear core is expected to reenter early next month.

24 Japan's National Space Development Agency (NASDA) will shortly select at least three astronaut candidates to begin training before the end of this year; one of them will fly as a Shuttle payload specialist in about 1987.

24 It is reported that the seventh Shuttle mission might land at the Kennedy Space Center, but only if conditions are good and there are no problems with the STS-6 landing.

25 The STS-6 mission is delayed until mid-March at the earliest after a second test firing of *Challenger's* main engines shows there is a hydrogen leak in one or more of them. The delay now means that later flights will be affected but the Dept. of Defense is insisting that its military STS-10 payload flies this year. Spacelab (STS-9) could now be pushed into 1984 and some satellites might be switched to the Delta rocket.

26 The Infrared Astronomical Telescope (IRAS) is launched by a Delta rocket from the Vanderberg Air Force Base in California at 02:17 GMT into a polar orbit. After a two-week testing period it begins the first all-sky survey of infrared objects (the January 1983 *JBIS* covers the mission in detail).

29 A 2 cm crack is found in *Challenger's* No. 1 engine (no. 2011) in a pipe routing hydrogen from cooling the engine back to the turbo pump. The engine will be replaced by flight spare no. 2016. Launch will be in mid-March at the earliest, later if a third engine firing is made.

31 The IRAS telescope's protective cover is ejected and the first infrared images of the sky are returned; more than 4,000 sources are detected on this first day. The rate of loss of liquid helium (used to cool the telescope to very low temperatures in order to observe IR objects) indicates a mission length of at least 250 days, more than enough time to scan the entire sky. The detectors prove to be 100 times more sensitive than previous missions.

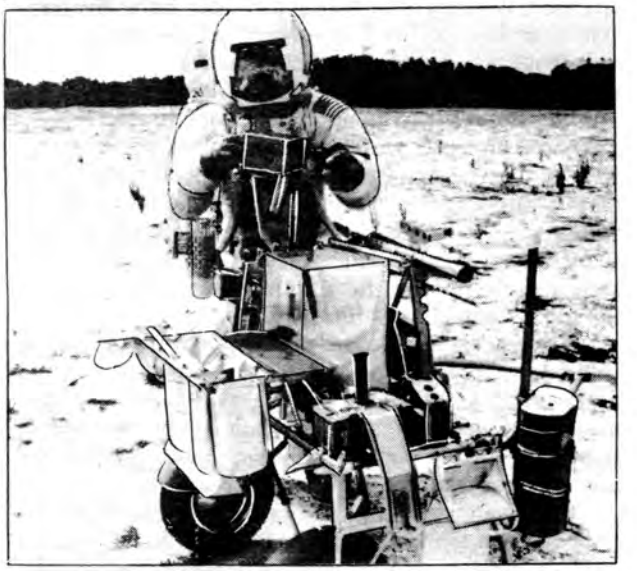
February 1983

7 The section of Kosmos 1402 carrying a nuclear core reenters the atmosphere and disintegrates.

14 The replacement Shuttle main engine (no. 2016) is confirmed as having an oxygen leak. Two further replacement engines (nos. 2007 and 2017) will now be brought to the Cape. No. 2007 was recently removed from Orbiter *Columbia* and returned to the manufacturers for modifications.

DO YOU KNOW?

For which Apollo mission is this astronaut training? The answer is right there in the photograph. A second question: Who was the first man to fly *alone* around the Moon? Answers to both are below the picture.



Answers: the Mobile Equipment Transporter (MET) seen in the foreground was used during Apollo 14 only; later missions carried the powered Lunar Rovers. The hand-pulled cart allowed Alan Shepard and Ed Mitchell to move further afield with their equipment than the two previous lunar landing missions. Part 2: John Young was the first solo lunar pilot, flying aboard Apollo 10 in May 1969. He is now awaiting his sixth space trip.

DO YOU REMEMBER?

25 Years Ago . . .

15 May 1958. The 1327 kg Sputnik 3 satellite is launched into orbit.

20 Years Ago . . .

22 April 1963. The last Mercury capsule is mated to its Atlas booster at Cape Canaveral in preparation for Gordon Cooper's mission.

7 May 1963. The experimental communications satellite Telstar 2 is launched.

15 Years Ago . . .

6 May 1968. Neil Armstrong ejects from the Lunar Module landing trainer seconds before it crashes.

10 Years Ago . . .

14 May 1973. The Skylab space station is taken into orbit during the final Saturn 5 launch.

5 Years Ago . . .

19 April 1978. NASA announces that two British scientists are candidate Payload Specialists for the Spacelab 2 mission (they were later eliminated).

D. J. SHAYLER

PERSONAL PROFILE

WILLIAM McLAUGHLIN

Looking Up and Starting Out

Some of my best days have been spent as a dedicated geocentrist, looking up at such spectacular celestial presentations as Comet Bennett in 1970, Nova Cygni in 1975, and the 1981 Siberian total eclipse of the Sun. However, no Earth-based visual experience could displace the memory of my first such sight: the October 1946 meteor shower occasioned by the close passage of the Earth to periodic Comet Giacobini-Zinner. I lay on my back in a park in River Forest, Illinois and tallied the flood of meteors on an old golf-stroke counter. The December issue of *The Griffith Observer*, to which I subscribed as a budding amateur astronomer, compared this shower favourably with notable meteor showers of the past and also reported that an excited citizen of Longview, California had telephoned the police to say: "The air is full of rockets and bombs! We are being attacked! What shall we do?"

My introduction to astronomy had come two years earlier at the age of nine through reading a school book. Soon afterwards my uncle, Edwin Irving, returned from the Pacific War where he had learned the constellations as a navigator, and passed some of this knowledge on to me. The combination of star-gazing and reading books that fired my imagination (Garrett Serviss' *Round the Year with the Stars* and the science fiction of Ray Bradbury and Isaac Asimov) left a permanent taste for space.

My formal education was completed by a PhD in mathematics from the University of California at Berkeley (1968) with a dissertation in celestial mechanics. In between I served a hitch in the US Marine Corps, wasted a lot of time playing chess, published a science fiction short story that the world has not yet adequately recognised, acquired a B.S. in electrical engineering and an M.A. in mathematics, started amassing a good library, and my wife Karen and I began raising our four children while we both worked or went to school.

It is always difficult to be objective in classifying one's own activity (other people fit neatly into their pigeonholes), and when I was asked to write this profile I had to struggle to achieve a sensible scheme; the purely chronological arrangement of facts seemed too inert. I decided that a better representation of my work could be given by grouping it into "investigations" and "projects and systems." The former is characterised by depth, restricted collaboration with other people, and publication of the results in journals. The marks of the latter include breadth, numerous and complex interfaces, and frequently the launching of the end product into space. Both types of activity are built up from those most important units of human activity: ideas.

Investigations

The first area in which my investigations have entered can be described loosely as "gravitational work." I stake a partial claim to the 20th or so most massive body in the Solar System, the satellite Rhea of Saturn. Tom Talbot and I conducted the last, extensive investigation of the gravitational environment of the Saturnian system prior to its penetration by spacecraft and, in the course of this work, made the first accurate determination of the mass of Rhea [1]. It has held up well in light of the Pioneer and Voyager results. The resulting familiarity with the Saturnian system led me to look into the question as to why the material in the rings of Saturn is, to the first order, most densely packed in the B-ring and then falls off in both directions, through the A and C rings. Explanations involving the gravitational effects of the inner satellites had failed to resolve the problem [2]. I found that a simple application of an old technique in statistical physics provided an explanation [3]. The technique was so appealing that I used it a second time to describe the distribution of short-period comets in the Solar System [4]. A fourth gravitational venture, in addition to Rhea, the rings, and comets, was chronologically the first: a method for representing gravitational fields by means of point masses. It was applied by a colleague to a lunar-gravity problem [5].

There is a book that lists about 2300 sequences of integers (whole numbers) in common use in mathematics, science, and engineering [6]. Out of curiosity I scanned these sequences and found that at least one, with slight modification, would do as well or better than Bode's numbers in describing the distances of the planets from the Sun [7]. In addition to yielding one more variation on Bode's law, this numerical experiment lends some empirical support to the belief that Bode's

description is "simple" in the sense that an equivalent to it was found in a basic store of sequences. The larger question as to the dynamical significance, if any, of Bode's formulation is still unresolved, e.g. see Ref. 8.

Watching Nova Cygni in 1975 gave me the thought that novae might serve as clocks in order to simplify the problem of interstellar communication, much as the "Water Hole" convention had helped to simplify the problem of introducing a precontact convention that, it was hoped, both parties to the communication attempt (them and us) would honour [9]. I wrote up the idea and Carl Sagan published it [10]. The fact that Makovetskii [11] and I independently thought of the clock convention suggests that it might also occur to alien minds. Incidentally, my "clock" yields favourable opportunities to conduct a radio-search experiment with respect to those Sun-like stars Tau Ceti and Epsilon Eridani in 1987 and 1988, respectively. A second foray into exobiology arose from an attempt to answer Enrico Fermi's question "where are the extraterrestrials?" in a manner other than "they don't exist" [12]. I postulated that advanced extraterrestrials are too difficult to observe and that one should change the question to: "where are the hominids?" Hominids are defined to be man-like, potentially observable extraterrestrials: the final stage in Darwin-Mendel evolution. I answered this revised question by: "they eventually lose out, in an evolutionary sense, to the machines that they create," i.e., they become extinct [13]. What a nasty subject evolution has proved to be! First Darwin questioned our past, and now I have cast doubts on our future.

A good deal of my recent work has been with Sylvia Lundy in developing new methods of celestial cartography to construct maps produced by use of spacecraft. The method also has application to planetary mapping missions. Only a preliminary report on "the transect method" is currently in print [14].

Projects and Systems

Space projects come in all sizes and shapes: from the Apollo/Viking/Voyager class, through the Explorer-class Earth satellites, down to an instrument carried aboard the Shuttle for a one-week demonstration.

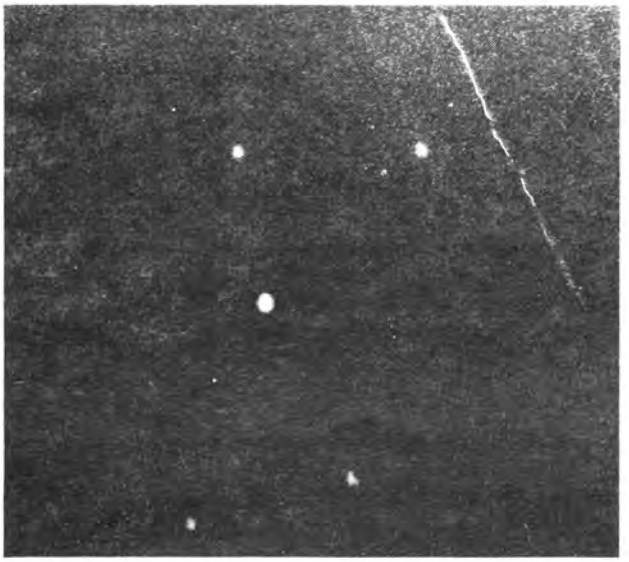
The primary characteristic of a project is that it is exciting. Next, it is a system, i.e., an interlocking complex of components which exchange information and requirements. An investigation can be open ended and the truth followed to its most promising conclusion, but a project has boundary conditions of budget, schedule and mission. Only the systems approach can cope with the strains induced by these boundary conditions.

My first introduction to a project came when I joined Bellcomm, Inc. in Washington, D.C. in 1968 and started to work on the biggest space project of all: the Apollo Moon landings. Bellcomm was a spin-off from Bell Telephone Laboratories at the request of NASA in order to provide Headquarters with a systems analysis capability to help with the massive problems that accompanied Apollo. The company existed for the ten years of the Apollo era, 1962–1972, and during its last few years was located a short way from NASA Headquarters, just south of the Washington Mall (and very well placed for noontime visits to the Smithsonian Institution galleries).

By 1968 the Moon was proving lumpier than expected, based upon tracking of lunar satellites, and this granularity was a concern for the proper functioning

The opportunity to work on a variety of space projects has been an experience beyond compare.

Personal Profile/contd.



Apollo 13 on its first night out from Earth, seen during the optical tracking program at Bellcomm. The docked craft are seen as the bright spot; the four surrounding objects are the discarded panels that once held the Lunar Module atop the Saturn third stage. Picture by Jim Young, Ellis Miner and Earl Ivie; reproduced with their permission.

of the Apollo navigational system. I devised a mathematical representation suited to this type of gravitational field (as mentioned in the preceding section), but at about the same time Muller and Sjogren of JPL came out with their famous results on lunar mascons [15]. So, rather than continue to adorn this edifice I took advantage of the opportunity provided by a request to Bellcomm for Apollo tracking information and built an independent, optical-tracking network for the spacecraft. This system was employed on Apollos 9 to 15 by Bellcomm to back up the conventional radio tracking. Since the story has been told elsewhere of how Jim Cappellari and I constructed and operated the network, the details of the venture will be suppressed [16,17,18]. We observed the explosion of the discarded Apollo 9 S4-B booster, the Apollo 13 oxygen-tank rupture, and several planned water dumps from the Command and Service modules.

But even mightly Apollo was mortal and as the programme, and Bellcomm, approached their end we packed up and left our home in green and leafy Annandale, Virginia for Pasadena, California in the dusty west. A second exciting, large project awaited me as I began work at the Jet Propulsion Laboratory in October 1971 on the trajectory software system for the Viking mission.

The computer program DPTRAJ (Double Precision Trajectory program) had been used by JPL for previous interplanetary missions and, in fact, is still the mainstay for projects such as Voyager and Galileo. However, it was due for a major modification for Viking applications so I set to work with a small staff of programmers on these tasks. It was an experience to learn how to manage a large software development in the rather hectic environment of Viking (the phrase "baptism of fire" comes readily to mind). The entire development, testing and documentation lasted until early 1975 when we delivered the finished product to the Viking project for integration into the overall navigation system. Along the way there were opportunities to help out on the Pioneer 10 and 11 navigation systems (JPL navigates these Pioneers for the Ames Research Center) and to work on revision of the solar-pressure model in DPTRAJ for the third encounter of Mariner 10 with Mercury (1975).

I took another excursion from the software development during my Viking days and tried to sell the project on the idea of putting a small, flat mirror atop the Viking Lander cameras in order to reflect sunlight into the Orbiter camera systems, 300-1500 km overhead [19]. In this way, the Lander locations on the surface of Mars could have been determined very precisely with respect to the surface features of the planet (the Viking Orbiter imaging systems did not have sufficient resolution to see the Landers from orbit [20]). Good idea, bad timing. The Viking project was scrambling to meet its development schedules and had no time for it. It was interesting, later, to see this same type of experiment actually performed from an Earth station, using the orbiting Landsat cameras [21].

In order to provide continuity between projects and to pass on the lessons learned in the Viking effort, I wrote software functional requirements for DPTRAJ for the Voyager project.

In mid-1975 the chance arose to do some mission design for an Earth-orbiter: Seasat, which was to carry the first of JPL's marvellous Synthetic Aperture Radars (SAR) into orbit [22,23].

The Seasat work was instructive and enjoyable, but in the summer of 1976 JPL was assigned responsibility for the US portion of the Infrared Astronomical Satellite (IRAS), and I practically went into orbit myself, boosted by enthusiasm for getting a job with that project (currently I am the Mission Design Manager for IRAS). The IRAS work has been representative of systems analysis at every stage of the project's development from conceptual design to operations this year. The principal challenges have been posed by the very advanced technology which the telescope represents and the consequent problems it yields for the conduct of an all-sky survey, together with the complex interfaces that ensure from working with our Dutch and British partners. It was good to get back into mission operations again in 1983; I hadn't been in that environment since the Apollo days.

A second astronomical task arose when in 1980 NASA asked JPL to look at the feasibility of conducting an all-sky survey by satellite in the extreme ultraviolet portion of the electromagnetic spectrum. It was requested that the study be completed rapidly. Upon being appointed study manager, I hastily assembled a team of specialists in spacecraft and mission design, information systems, mission operations and cost estimation. Within two months we had produced a comprehensive design for the satellite, costed it, and shortly after presented the results to NASA Headquarters. Following this work the Extreme Ultraviolet Explorer (EUVE) was assigned to JPL for development (see "Space at JPL" in the March *Spaceflight*).

Since 1981 I have been able to mix further variety into the IRAS work by virtue of supervising the Ter-

restrial Planets Mission Design Group at the Laboratory. My domain extends out to the asteroid belt where my colleague Paul Penzo, who supervises the Outer Planets Mission Design Group, and I draw the line (I claim that the asteroids fall on my side of the line). Within this domain lie Earth orbiters, missions to Venus (VRM), the Sun (ISPM), and potentially the Moon, Mercury, and Mars.

Was ever a king so rich!

Alarums and Excursions

Too much organisation can prove stultifying, so in this last section I will just set down a few notes on disparate subjects.

Having emphasised the primacy of ideas in astronautics, it seems appropriate to list my candidates for the five best ones:

1. staging of rockets (Simienowics, 1650),
2. radio tracking (Huelsmeyer, 1904: patent for navigational use on the Rhine River),
3. gravity assist (Hohmann, 1925; del Rey, 1939),
4. synchronous orbit for communications satellites (Clarke, 1945),
5. the decision to go to the Moon (Kennedy, 1961).

Reading and enjoyment of the arts have always provided great pleasure to me. I consider astronautics and the arts to be related since both are worthy human pursuits which are self justifying: "end activities." My master is Will Shakespeare of Stratford and London. The fundamental subsystems of the aesthetic endeavour are, in my judgment: poetry (Keats), prose (Conrad), painting (Pissarro), music (Bach), philosophy (Plato), and mathematics (Gauss). Restricting the list to the 20th century (with apologies to Conrad): Dylan Thomas, Ernest Hemingway, Pablo Picasso, Charles Ives, Alfred North Whitehead, Henri Poincaré.

For relaxation I like to read, travel [24], write [25], study Latin as time allows, star-gaze (with care in selecting the southern horizon, Canopus can be seen in winter from Los Angeles), watch old movies on television (Stan Laurel and Oliver Hardy are best), and do abstract mathematics (some recent results in probabilitistic number theory should be publishable).

For the future I look forward to working on the good things we bring into JPL and producing a significant corpus of work. The Society's Daedalus proposal would be a challenging project to implement. In the second category, a truly significant discovery is probably a matter of luck as well as hard work; I'm keeping my fingers crossed for first contact with extraterrestrial intelligence and a proof of Fermat's Last Theorem.

Acknowledgements

To Eileen K. McLaughlin and the late William L. McLaughlin for all the essentials; to teachers of excellence Cathryn C. Dirksen of Washington School and Stephen Diliberto of Berkeley; to Karen McLaughlin for graduate school and all that followed; to colleagues early and late: Ed Irving, Tom Karras, Frank Romeo, Jim Cappellari, Tom Talbot, Dave Smith, Joe Cutting, Sam Dallas, Sylvia Lundy and Len Carter; and to the perspective provided by friendship with two good dogs, Shadow and Arthur.

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25. Largely a vestigial pleasure except for my professional papers. Perhaps my current series in *Spaceflight,* "Space at JPL," signals a renaissance with the pen.

* * *

PARIS IN THE AUTUMN

T 33
Part 2

In the April issue (pp.170–172) we carried the first part of a report on last year's IAF Congress in Paris. Here we conclude the report with individual looks at some of the sessions.

HISTORY OF ASTRONAUTICS

This was a hectic symposium with some ten papers being packed into one three hour afternoon session, which effectively meant that it was not possible to do justice to any of the papers. That the symposium itself ran so smoothly is a credit to the co-chairmen Fred Durant and V. N. Sokolsky, and to the discipline of the authors. Without wishing to appear contentious, it would have been far more sensible to have allocated two sessions rather than one to this history symposium. With history being created every day in the field of astronautics, interest in this aspect of the subject must grow, and I hope that the IAF Programme Committee will bear this in mind in planning future Congresses.

Three of the most interesting papers presented were from the USA, one by Martin Summerfield of the Princeton Combustion Research Laboratory and two by Fred Ordway from the Alabama Space & Rocket Center. Summerfield's paper, entitled "Fundamental Scientific Questions in the Early Period of Rocket Propulsion Development", was also the most contentious. Summerfield collaborated with Dr. Frank Malina during the early years of USA rocketry, and the basic tenet of his paper was that there is very little sign of a direct descent from the German V2 rockets to present day rocket technology, but rather that modern rocket engines can be traced back directly to the work done at GALCIT at the California Institute of Technology. This conclusion will not be readily accepted by many space historians and the paper promises to fuel the fires of discussion for many years to come. Fred Ordway spoke on the early years of Reaction Motors Incorporated, an American company which was one of the pioneers of rocket technology. This paper was co-authored by Frank Winter from the National Air and Space Museum in Washington. Reaction Motors, now part of Thiokol Chemical Corporation, was formed in December 1941 to develop the work on rocketry carried out by the American Rocket Society. The paper traced the history of the company through to the development of Viking, the USA's first large liquid-fuelled rocket. Ordway's other paper "The Evolution of Space Fiction on Film" was well received by all present, possibly as a means of light relief.

Two papers from the USSR, "The Development of Space Psychology" authored by G. Beregovoy and N. Krylova and read by Dr. Besenko, and "On Rocket Personnel Training in the USSR (1924–1926)", read by V. N. Sokolsky, were presented. The latter, written by E. Moshkin and A. Nistratov covered the establishment of public organisations in the USSR to popularise rocketry, etc., during the late 1920's.

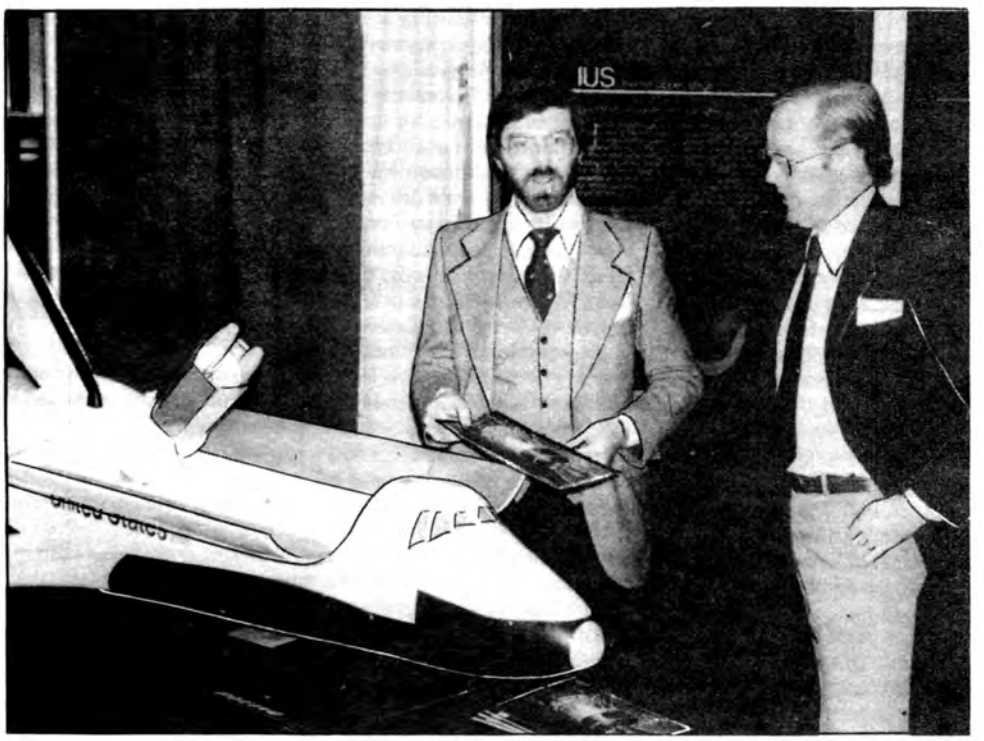
One of the last papers in the symposium on a totally different subject altogether was given by Michele Van Hollebeke. This described the future Space Science and Technology Exhibition to be opened at the Parc de La Villette in Paris in 1984. La Villette will be the French equivalent of the "Science Centre" so popular in the USA.

In conclusion: a well attended, active symposium which suffered somewhat from lack of time allocated.

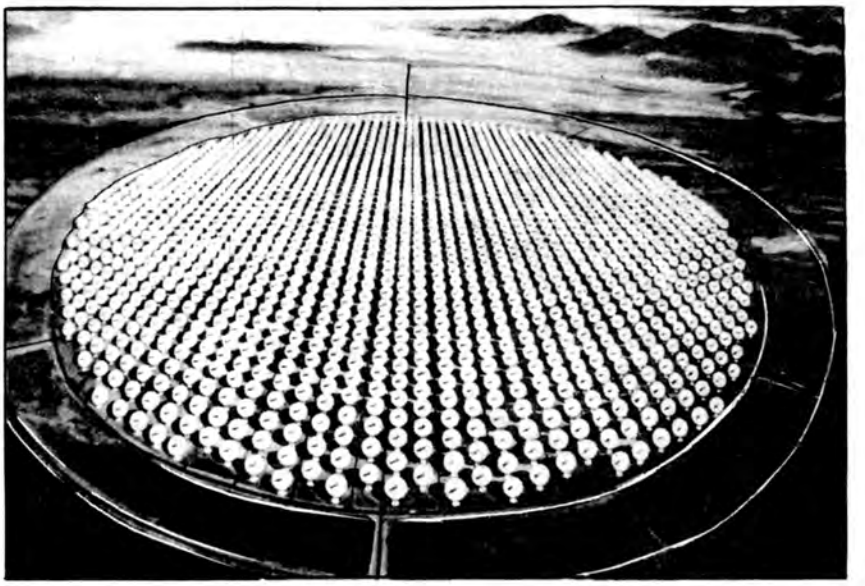
JOHN BECKLAKE

CETI

This meeting was divided into two half-day sessions and the subjects ranged from reports of searches for signals from outer space, through studies advocating a search for evidence of life in plantary atmospheres and the asteroid belt, to a report on SETI games carried out in Paris. One problem with CETI meetings is that most presentations are either negative results from searches for extraterrestrial intelligence



Not the IAF Paris meeting but the AIAA Biennial Space Systems Conference held in Washington DC last October. Ian Pryke (right) and Andrew Stimson report on the conference in April's "Space Chronicle" issue of the Journal.



The "Cyclops" SETI proposal of 1971: a huge array of antennae would search for signals of extra-terrestrial origin. Such a system would be very expensive.

or proposals for searches which will probably not be undertaken because of "higher" priorities. Such continuing content could tend to deaden the enthusiasm of all but the most devoted CETI advocate.

This theme of the relative lack of support for CETI projects was the subject of a paper by D. Goldsmith of Interstellar Media, Berkeley, California. He postulated that to obtain governmental and hence financial support we must have the public behind CETI. To do this we must convince the public that UFO's do not exist or at least are not visitors from other civilisations, and that if we are going to make contact with extraterrestrial civilisations we must actively search for them and not expect the contact to come knocking at our door.

Another phase of the SETI games project in Paris was reported by A. Ducrocq at this Review Meeting. Previous experiments, where groups of teenagers with flashlights were stationed at line of sight points in Paris and asked to establish contact with other groups against the background lighting of Paris, all failed. These experiments were reported at the 1980 and 1981 Congresses. In the new experiments, two groups were placed in contact over a short distance and were asked to communicate information to each other *via* flashlights (excluding the use of morse code I assume). No exchange of information was obtained.

The meeting also included papers of CETI observations and programmes, carried out on the Nancay Radio Telescope in France, reported by F. Birand (Observatoire de Paris); on the Westerbork Synthesis Radio Telescope in the Netherlands, authors J. Tarter (University of California) and G. Shostak (Kapteyn Astronomical Institute); and the Arecibo Telescope, authors J. Tarter (University of California), R. Duquet (National Radio Astronomy Observatory), T. Clark (NASA GSFC) and M. D. and L. Lesyna (Stanford University).

JOHN BECKLAKE

SPACE & EDUCATION

The session covered a spectrum of supervised youth activities and research projects, ranging from the NASA-sponsored projects by high school students, as well as Getaway Special student experiments aboard the Space Shuttle, college level aerodynamic experiments using ping pong balls and model rockets, to supervised experimental rocket projects in France and Yugoslavia.

In addition, the early CALTECH years of Dr. Frank Malina were discussed in relation to the development of supervised youth space-related experiments safety concepts.

Among the highlights of the session were the slides, shown by Dr. Glen Wilson formerly of NASA, of the student experiment flown aboard the Shuttle, *Insects in Flight in Motion Study* by Todd Nelson. A paper available only in abstract pointed out that Nelson's experiment represented the successful conclusion of nearly a year of close cooperation between private industry, teachers and space officials. It was, in fact, an experiment in cooperation.

The slides and films from France and Yugoslavia, showing excellent supervised programmes, indicated the continuous need for disseminating information to educators and supervisors regarding safe procedures.

A paper entitled "Stalking the Getaway Special – Student Adventures on Board the Space Shuttle" detailed the highly innovative concept for encouraging participation in space experimentation by an entirely new class of investigator. It referred to the space now being provided within the Shuttle cargo bay to permit individuals and institutions throughout the world to perform investigations in space on their own initiative. The cost to fly the experiments ranges from $3,000 to $10,000, and over 50 reservations have come from outside the United States, including Great Britain, West Germany, Denmark, Canada, Japan and Egypt.

George James, National Science Foundation, presented a paper written with F. H. Winter, National Air and Space Museum, which was a tribute to the late Frank J. Malina (1912–1981), who is well known to IAF members and to aerospace historians for co-founding the Jet Propulsion Laboratory.

Professor G. Gregorek of the Ohio State University described how 120 Aeronautical and Astronautical Engineering students built and flew 60 model rockets to launch ping pong balls. The task was to predict the time of fall for the balls from ejection to arrival at the ground. This was a real "hands-on" project and the Professor's enthusiasm in giving the presentation reflected the whole-hearted support given by the students.

E. A. QUARTERMAN

COMMUNICATIONS

The session on "Domestic and Regional Communications Satellite Systems" was well attended, with a high standard of presentation. Only the first paper, "Designing the next-phase domestic satellites – a step to communication satellites as intelligent network nodes" could be considered as a truly technical one. It outlined the problems to be solved for satisfying the conflicting needs of business services and more conventional telecommunications. It gave some solutions.

The other seven papers were mainly descriptions of current and immediately projected telecommunications satellite programmes, namely those of EUTELSAT and ARABSAT, those of the Japanese, the Canadians, the United Kingdom, the French, and those of one US company. Treating these papers together, they showed the increasing interest of the world in telecommunications satellites. The growth of digital traffic volume has clearly been identified by telecommunication authorities. Another trend is to the more efficient utilisation of the allocated frequency bands by improved modulation methods. It was interesting to learn of the 50 GHz transmission link equipment of the Japanese. It was apparent that the same spacecraft will be used, in the immediate future, for both fixed services and broadcast services, as opposed to the use of separate dedicated spacecraft. The size of spacecraft is increasing, necessitating the development of appropriate launch vehicles or the use of clusters of satellites or making satellites in orbit by rendezvous and docking techniques.

It was apparent that more and more nations are entering the field of the satellite telecommunications business.

TED MALLET

Right: Ted Mallet, Who reports on the communications sessions; *below:* Krafft Ehricke, who covers space benefits.

SPACE BENEFITS

A preliminary assessment for nuclear waste disposal in space, presented by a US team, described a risk model approach to estimate the non-recoverable, cumulative expected radionuclide release to the terrestrial biosphere for different options of nuclear waste disposal in space. The results were compared with risk estimates for waste disposal in mined geological repository. Consequences of accidents were characterised in terms of the release of radionuclides. The major goal was to develop the risk associated with space disposal, in terms of probabilistic unrecoverable cumulative releases to the biosphere from launch to one million years. It showed that the preliminary estimates of space disposal risks are low, even with the estimated uncertainty bounds. It was also found that, if calculated release risks for mined geological repositories remain as low as given by the US Dept. of Energy, and if US Environmental Protection Agency requirements continue to be met, then no additional space disposal study effort in the US is currently warranted. If publicly perceived risks are significant in association with geologic repositories, consideration should be given to space disposal as a complement to geologic repositories.

A. J. Kelley reported on results concerning the evaluation and selection of space application projects. He emphasised the importance of adapting the methodology of investment analysis, a rigorous, tested, pragmatic approach. It is important to define clearly investment criteria and decision points; to look at specific product definitions, their potential, pricing, running (operating) costs, profits and returns on investments. The "mystique" of space financing is thereby removed. The associated risks are either reduced or, at least, better understood by surfacing financial factors associated with a given project. In spite of the frequent difficulties in determining costs and benefits realistically, a growing body of data is becoming available on space operations. These, however, will not be of any benefit if they are not applied to a rigorous investment analysis.

An international private-sector satellite search and rescue locating system (SARSAT) was considered. The purpose was to demonstrate that satellites can significantly enhance search and rescue efforts by monitoring, detecting and locating distress messages from Emergency Locator Transmitters and Emergency Position Indicating Radio Beacons. The author presented a rationale for creating an international private sector (INSARSAT) organisation to establish, finance and operate an international satellite aided search and rescue locating system. A dedicated SAR network must be optimised for search and rescue. Placement in geosynchronous orbit would provide near-instantaneous warning, but poor locating accuracy. Low Earth orbits reduce power requirements and antenna sizes, and permit more accurate doppler locating. To avoid long detection delays, more satellites are needed; and to minimise reporting times, either expensive multiple ground stations are needed or high-gain satellite relays must be available. The satellite system involves no new technology development. Given a maturing technology and the political opportunity, the author concluded that a perhaps more efficient implementation of this humanitarian objective could result from normal marketplace activity of a private sector multi-national corporation.

B. J. Bluth discussed the benefits and dilemmas of an international space station. To optimise its use requires concern for special problems of stress in isolated, confined environments, and how those problems are affected by language and cultural differences. Work in Antarctic bases

Paris in the Autumn (Part 2)/contd.

and oceanographic vessels, for example, show that problems in common restricted environments, in some cases, seriously affected the success of the entire mission. Situations with international crews point to language and culture as sources of error and misunderstandings.

K. A. Ehricke discussed a system of lunar economics and cislunar/terrestrial market analysis. Economically successful lunar industrialisation requires a development strategy specifically designed to balance investments and returns as attractively as possible.

Two other papers dealt with more general subjects. One discussed the question whether the space station is essential to maximising socio-economic benefits. He concluded that the USSR has a major commitment to space not in evidence in the West, and that, while the station makes sense now, no good case for it has been made. The second raised the prospect of disruption of Third World societies by space developments, drawing analogies to disruptions by earlier technological progress. Once a technology is cheap or widespread enough, it will have an effect; and every effective technology disrupts, thereby changing old orders.

KRAFFT EHRICKE

LEGAL DISCUSSIONS

One of the four sessions at the 25th Colloquium of the International Institute of Space Law concerned legal aspects of direct broadcast satellites (DBS). Five of the 14 papers prepared for the session were presented by their authors: "Legal Aspects of the European Direct Television Satellite (L-SAT)" (M. Bourely, France); "Legal Aspects of Direct Broadcast Satellites" (A. Carnelutti, France); "National Claims for the Using/Sharing of the Orbit/Spectrum Resource" (C. Q. Christol, USA); "National DBS Programme of European Countries" (S. Courteix, France); and "Direct Broadcast Satellites and Ecospace" (E. R. Finch, USA).

The focus of the presentations and discussion at the session concerned the advantages and disadvantages of having the UN General Assembly vote on the draft principles which have been debated within the UN system for the past decade, rather than continuing to try to reach consensus.

In 1981, after nine years of unsuccessfully attempting to reach consensus within its legal subcommittee, the UN Committee on the Peaceful Uses of Outer Space (COPUOS) sent the draft DBS principles to the UN General Assembly (UNGA) for action. The UNGA decided to send the principles back to COPUOS for another attempt at reaching consensus in the committee's 1982 session, but no further progress was made. As a result, COPUOS has once again sent the draft principles to the UNGA for action during its 1982 session. B. Mayorsky (USSR) stated that he "regretted" this pattern of development, but supported the idea of the UNGA voting on the draft principles, and noted that in this event, the principles would have the status of a declaration of the UNGA, and would be non-binding recommendations. A. Carnelutti (France), on the other hand, commented that he would consider a vote to be "most regrettable," and added that amendments could arise in the Special Political Committee and the end result might be "quite disastrous." Noting that the UN had already adopted legal norms in this regard as part of a 1972 UNESCO declaration, he asked: "Is that what we're looking for; a voted instrument of a non-binding nature? That's not law, that's a series of statements that would end up in anarchy." C. Colliard (France), President of the IISL, agreed that a vote would be unfortunate and an unsatisfactory result.

E. Finch (USA) suggested that final action on DBS principles be deferred until after the International Telecommunication Union (ITU) had concluded its meetings on the utilisation of geostationary orbit (the 1983 Region 2 conference on DBS in the 12 GHz band, and the 1985/87 Space World Administrative Radio Conferences) where this topic could be discussed on its scientific merits. C. Okolie (USA) supported Finch's proposal on the basis that consensus is necessary and obviously will not be reached soon.

MARCIA SMITH

BIOLOGY AND MEDICINE

Eleven papers were scheduled for presentation, but luckily several were withdrawn which made the session manageable. The greatest interest was shown in the report by G. Clement of CRNS in Paris of the results of the Posture Experiment flown on the recent joint Russian/French manned space flight. This experiment was designed to study the problem of movements in space and whether, for example, muscle reactions are the same in weightlessness as they are on Earth. Jean-Loup Chretien, the French cosmonaut, who flew on Soyuz T-6 to the Salyut/Soyuz T-5 Space Station (24 June to 2 July 1982), was present and able to answer many of the questions. One interesting side issue was the loss of Jean-Loup's tennis form after return from space. Jean-Loup is a good tennis player, but on return he found he could not play decently even though his motor reactions were back to normal. This situation did not persist for long. Another paper was presented by F. Patat on the measurement of blood flow in the cosmonauts during this mission.

J. Billingham from NASA spoke on the design considerations for human habitats in space. This study investigated the cost factors involved in producing various environmental conditions on a long-stay manned space station. The parameters considered were changes in gravity, pressure and atmospheric composition. It was found that by far the greatest cost saving could be made in switching from an O_2/N_2 mixture to an O_2/He atmosphere. The next step must then to be study whether man could in fact live and work safely in such an environment.

A team of scientists from the University of Houston in Texas reported on the results of the Plant Growth Unit experiment flown on the STS-3 mission in March 1982. This Unit grew Slash Pine, Mung Bean and Oats in space and investigated their production of lignin (a plant polymer). Since gravity is believed to be a primary controlling stimulus in lignification, a weightless environment offered an excellent tool for testing ideas concerning the mechanism of lignin formation. Other papers included the results of biological experiments to study the effect of stress in space in rats, flown on the Russian Biosatellites Cosmos 782, 936 and 1129, and reported by the Institute of Experimental Endocrinology, Bratislava, Czechoslovakia, and a review of the main medical results of recent Russian space flights. This paper was presented by the Institute of Biomedical Problems USSR, Ministry of Health, Moscow.

JOHN BECKLAKE

OBITUARY

Olgierd Wolczek

It is with regret that we record the death of Dr. Olgierd Wolczek, a member of the BIS for the past quarter century. He was a founding member, and General Secretary for 15 years, of the Polish Astronautical Society, producing many books and papers on astronautics, nuclear physics and related topics. He was also editor of the magazine "Astronautyka" and "Progresses in Astronautics" for many years.

JOHN YOUNG:

PART THREE

ONE MAN'S CONQUEST OF SPACE

By David J. Shayler

The first two parts of this series concentrated on veteran astronaut John Young's early career and the events leading up to the launch of Gemini 3. Here, we follow John through that mission and on to the commander's position for Gemini 10.

Journey to Orbit

Gemini 3 lifted off so smoothly that Young could not detect the upward movement; it was only the running of the clock and Cooper's verbal confirmation that told him they were on their way. The first stage shut down after 2½ minutes, plunging the crew down from 6g to 1g almost immediately. The ignition of the second stage bathed the cockpit in orange-yellow light, distracting Young for a few seconds until he realised its cause [1].

For two minutes the second stage pushed Young and Grissom towards orbital insertion high above the Atlantic Ocean and Young was drawn to the fantastic view of the horizon. Orbital insertion occurred at 00:05:34 GET (Ground Elapsed Time), shortly after the shutdown of the second stage. The capsule was severed from the now-spent Titan stage and placed in its initial orbit of 122X175 km by Grissom firing the aft thrusters.

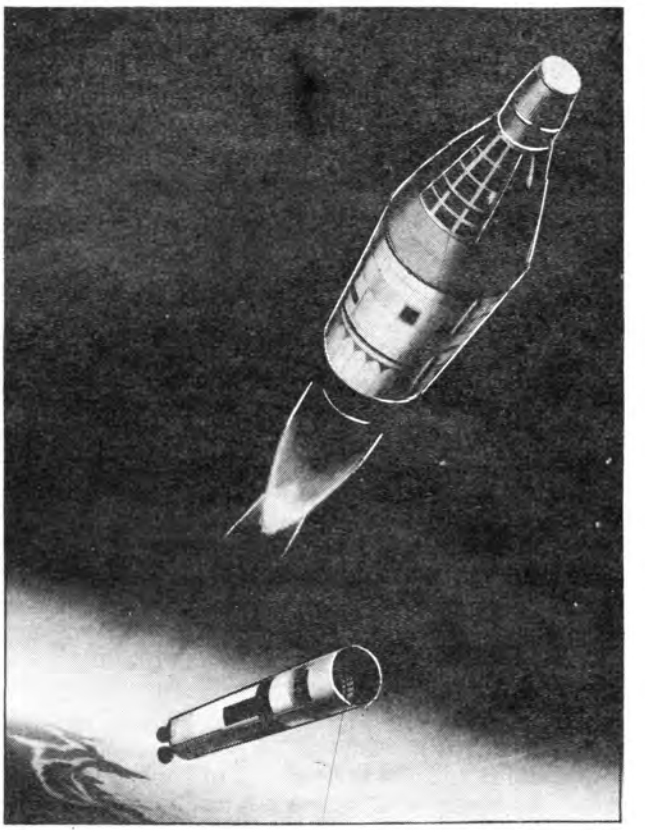
Molly Brown coasted out over the Atlantic and across Africa with the two astronauts performing checks on the spacecraft. At approximately 00:20 GET Young noticed a drop in an oxygen pressure gauge and at first assumed a problem with the environmental control system. He glanced at the other instruments, decided that the problem lay with the instrument itself, and switched to the secondary power supply for the dials. The problem immediately disappeared, with the gauge reading normal pressure.

Orbital Manoeuvres

At 01:33 GET, on the first orbit high above Texas, the crew achieved a space first by changing their craft's orbit and placing it in one of 157 by 169 km. The 74 second burn slowed the vehicle by 15.2 m/s.

During the mission the crew were to perform a series of simple scientific experiments, as well as make a complete check of the new manned spacecraft itself. Young was assigned to monitor a radiation experiment which, although it gave him some trouble, he was able to complete.

A second firing of the thrusters at 2 hours 18 minutes into the mission changed the vehicle's orbit once more, and during the third and final orbit, at 04:21 GET, the thrusters were again fired, this time for 109 seconds, slowing the spacecraft by 29.26 m/s in a pre-retrofire manoeuvre. This ensured a "natural" re-entry in the event of a retro-rocket failure.



Artist impression of the Gemmini capsule and its Titan II second stage pulling away from the spent first stage.

Martin Co.

Coming Home

Firing of the retros followed shortly and Gemini 3 arced back towards Earth. Re-entry was, according to Young and Grissom, very close to their simulations. At about one minute into the re-entry sequence, after the plasma sheath had formed, Young activated an experiment to see if communications could be maintained for longer than previously possible. The results were encouraging, with UHF and C band signals reaching the ground.

As the spacecraft dropped through the atmosphere it became apparent that it would miss the planned landing point because it did not have the lifting capability predicted by wind tunnel tests. Despite two banking manoeuvres, the vehicle headed for a splashdown some 84 km short of the planned site.

While suspended under the canopy of the recovery parachute, Grissom threw the switch to put the craft in the recovery attitude, with the 'chute supporting it at two points. The craft dropped with such force that both men were thrown against their hatches; Grissom's faceplate broke and Young's was scratched.

Molly Brown hit the water 4 hours and 53 minutes after leaving the pad. Since the prime recovery vessel was nearly 110 km away, due to the short landing, a helicopter was sent from the closer Coast Guard cutter *Diligence*.

After splashdown, the crew released the parachutes and waited 28 minutes for the swimmers to arrive. The heat and confines of the cockpit, coupled with a 1½ m swell, were not very comfortable and Grissom was sick. Young later said that "it's a wonderful spacecraft but not much of a boat"[2].

Once the flotation collar was attached, the hatches were opened and the crew were hoisted aboard the helicopter for the trip to the prime recovery vessel, *USS Intrepid* [3].

After the Flight

After a day of medical examinations and congratulations, the crew were flown to Cape Kennedy, where they underwent yet more physicals and spent hours with technicians and engineers on more debriefings. During a news conference, Young described the experiments he had conducted with the food, water and waste disposal systems being developed for longer missions. The crew also reported on the famous corned beef sandwich episode. The sandwich had been bought by astronaut Wally Schirra from a cafe in Cocoa Beach; he gave it to Young to be smuggled aboard. Whilst in orbit Young produced the sandwich, much to the surprise of Grissom, who promptly took a bite or two.

Although not serious, this episode concerned some members of Congress as it was contrary to the flight plan. Repercussions from Congress resulted in Deke Slayton sending a memo to all NASA astronauts on the incident: ". . . the attempt . . . to bootleg any item onboard not approved by me will result in appropriate disciplinary action. In addition to jeopardizing your own personal careers, it must be recognized that seeming insignificant items can and have affected follow on crews"[4]. However, the incident did not seem to hinder the future NASA careers of the two men.

On 3 May 1965, Young was awarded US Navy Astronaut Wings [5], and on 22 June he was nominated for promotion by President Johnson, following the tradition whereby all military astronauts received promotion after their first flight. Young rose to Commander from Lt. Commander [6].

Gemini 6

Just 14 days after flying in Gemini 3, Young was named as backup pilot for Gemini 6, then intended to be the first rendezvous and docking mission [7]. Young again teamed up with Grissom, this time working with their Gemini 3 backups, Schirra and Stafford.

Early in the morning of 25 October 1965 Young and Grissom were inside the Gemini 6 capsule, setting the controls prior to the entry of the flight crew a few hours before the schedule lift off. However, due to the loss of the Agena target vehicle, the mission was scrubbed. A few weeks later it was revealed that Gemini 6 would rendezvous with Gemini 7. The prime and backup crews for both mission now teamed up to train for the joint mission that December.

December 14, launch day for Gemini 7, saw Young as one of ten fellow astronauts who breakfasted with the Gemini 7 crew. A few hours later Gemini 7 was in orbit and Young and Grissom were preparing for a Gemini 6 launch attempt in eight days time.

On 12 December they were again in the Gemini 6 capsule, setting the spacecraft for launch configuration. This launch was also scrubbed, however, due to a faulty electrical connection causing a shut down of the first stage 1.2 seconds after ignition. Schirra and Stafford elected to stay aboard and not eject, thus saving Gemini 6 for another day.

On 15 December Young and Grissom climbed into the capsule to prepare for a third launch attempt. This time the launch occurred on time, with Schirra and Stafford rendezvouing with Gemini 7 a few hours later [8].

With the completion of Gemini 6 Young and Grissom split up as a crew after 20 months together; they had built up a good reputation together and were good friends. Grissom was now assigned to Apollo with Ed White and Roger Chaffee.

Young, meanwhile, remained with Gemini. The commander's seat in Gemini 10 was vacant due to the departure of Ed White to Apollo and Young was assigned to this flight. His pilot would be Mike Collins, former backup pilot for Gemini 7. Young and Collins teamed up in January 1966 and were officially announced as the prime crew for Gemini 10 on 25 January [9]. For the third time Young started the Gemini training programme.

To be continued

Acknowledgments

Listed in Parts 1 and 2 of this series.

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SATELLITE DIGEST – 163

Robert D. Christy
Continued from the March issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

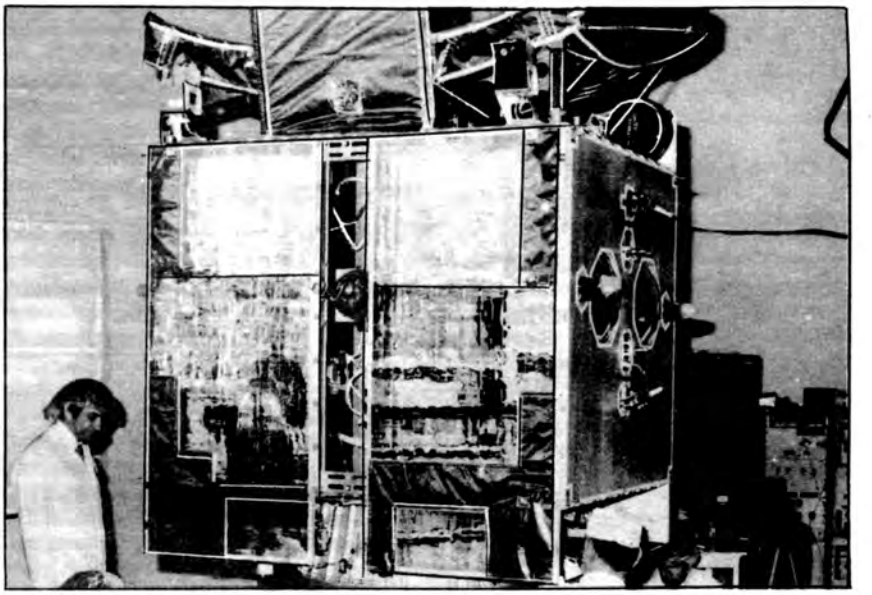
GORIZONT 6 1982-103A, 13624
Launched: 1635, 20 Oct 1982 from Tyuratam by D-1-E + apogee motor.
Spacecraft data: Cylinder with a pair of solar panels, an array of aerial horns and reflectors is located at the Earth pointing end of the satellite, which is three axis stabilised. Length is about 5 m, and max. diameter about 2 m, the mass is around 2000 kg.
Mission: To provide telephone, telegraph and television relay links through the "Moscow" system both within and outside the USSR.
Orbit: Initially a low parking orbit at 51.6 degrees inclination, then transferred to an elliptical parking orbit at 47 degrees prior to injection into a geostationary drift orbit before eventual stabilisation, apparently at 90 degrees east longitude (Statsionar 6?).

COSMOS 1418 1982-104A, 13627
Launched: 1410, 21 Oct 1982 from Kapustin Yar by C-1.
Spacecraft data: not available.
Mission: possibly radar calibration.
Orbit: 370X414 km, 50.67 degrees, 92.33 min.

RCA SATCOM 5 1982-105A, 13631
Launched: 28 Oct 1982 from Eastern Space and Missile Center.
Spacecraft data: Box-shaped body approx. 1.4X1.6X1.8 m, with solar panels, mass approx 600 kg.
Mission: US domestic and international communications.
Orbit: Geostationary.

DSCS 15 & DSCS 16 1982-106A&B, 13636 & 13637
Launched: 30 Oct 1982 from Cape Canaveral Air Force Station.
Spacecraft data: not available.
Mission: Missile Early Warning satellites.
Orbit: Geostationary.

PROGRESS 16 1982-107A, 13638
Launched: 1120, 31 Oct 1982 from Tyuratam by A-2.
Spacecraft data: Similar in appearance to Soyuz-T except that the re-entry module is replaced by a cone shaped non-recoverable section for stores.
Mission: To carry consumables and experimental materials to the long-stay crew aboard Salyut 7. Progress/6 docked with Salyut's rear port at 1322, 2 Nov 1982. It undocked 13 Dec and was later commanded to re-enter the Earth's atmosphere.
Orbit: Initially 186X245 km, 88.75 min, 51.62 degrees, then transferred to 289X354 km, 90.91 min, 51.63 degrees. After docking with Salyut, the orbit was 353X362 km, 91.64 min, 51.62 degrees.



RCA Satcom 5 was launched on 28 October 1982. Five of the series are now in orbit, providing domestic communications for the US.

RCA Astro-Electronics

COSMOS 1419 1982-108A, 13641
Launched: 0930, 2 Nov 1982 from Tyuratam by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical reentry module, instrument unit and a cylindrical supplementary payload at the forward end. Length about 6 m, max. diameter 2.4 m, mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 228X285 km, 89.64 min, 70.34 degrees, manoeuvrable.

COSMOS 1420 1982-109A, 13648

Launched: 0615, 11 Nov 1982 from Plesetsk by C-1.
Spacecraft data: Not available, but may be similar to the Cosmos navigation satellites, ie a cylindrical body with domed ends, enclosed in a cylindrical solar array with length and diameter both about 2 m, mass around 700 kg.
Mission: Military communications using a store/dump technique.
Orbit: 780 X 810 km, 100.80 mins, 73.99 degrees.

STS 5 1982-110A, 13650

Launched: 1219*, 11 Nov 1982 from launch complex 39, Kennedy Space Center.
Spacecraft data: Re-usable shuttle *Columbia*.
Mission: First operational flight of the Space Transportation System, involving the deployment of two satellites and attached rocket motors for transfer to geostationary orbit. The crew consisted of Vance Brand, Robert Overmeyer, Joseph Allen and William Lenoir, the first launch of a four man crew. *Columbia* landed on the concrete run-

way at Edwards AFB, California 1433, 16 Nov 1982.
Orbit: 294 X 317 km, 90.49 min, 28.47 degrees.

SBS 3 1982-110B, 13651

Launched: 2017*, 11 Nov 1982 from the payload bay of *Columbia*.
Spacecraft data: Cylinder, 6m long, 2m dia, mass about 580 kg.
Mission: Business communications.
Orbit: The first motor firing after leaving the Orbiter resulted in an elliptical, geostationary transfer orbit, a later motor firing circularised it near geostationary altitude before the satellite drifted to its operational location of 94 degrees west.

TELESAT 6 1982-110C, 13652

Launched: 2024*, 12 Nov 1982 from the payload bay of *Columbia*.
Spacecraft data: Cylinder, 2m long, 1.5m dia, mass about 2,100 kg (fuelled).
Mission: Canadian government communications satellite.
Orbit: The first motor firing after leaving the Orbiter resulted in an elliptical, geostationary transfer orbit, a later motor firing resulting in a near circular geostationary drift orbit before final positioning above 112.5 degrees west.

OPS 9627 1982-111A, 13659

Launched: 2130, 17 Nov 1982 from Vandenberg AFB by Titan 3D.
Spacecraft data: Cylinder, length about 15m, diameter 3m, mass about 13,000 kg.
Mission: KH-11 type satellite providing reconnaissance pictures *via* a TV transmission system.
Orbit: 281 X 518 km, 92.61 min, 96.97 degrees.

COSMOS 1421 1982-112A, 13661

Launched: 0930, 18 Nov 1982 from Tyuratam by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical reentry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6m, diameter (max) 2.4m and mass around 6,000 kg.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 230 X 280 km, 89.62 min, 70.34 degrees, manoeuvrable.

ISKRA 3 1982-33AD, 13663

Launched: 18 Nov 1982 from Salyut 7.
Spacecraft data: Not available.
Mission: Experimental amateur radio relay.
Orbit: 350 X 365 km, 91.5 min, 51.6 deg.

RADUGA 11 1982-113A, 13669

Launched: 1430, 26 Nov 1982 from Tyuratam by D-1-E.
Spacecraft data: Cylinder with a pair of solar panels, and an aerial array at one end. Length about 5m, diameter (max) about 2m and mass around 2,000 kg.
Mission: To provide round-the-clock radio and telegraphic communications in the UHF band and to relay Central Television programmes to stations of the "Orbita" network.
Orbit: Initially a low parking orbit at 51.6 degrees, then to an elliptical transfer orbit at 47 degrees prior to injection into a geostationary drift orbit before final stabilisation at 35 degrees east.

COSMOS 1422 1982-114A, 13677

Launched: 1200, 3 Dec 1982 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1421.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 228 X 288 km, 89.68 min, 72.85 degrees manoeuvrable.

COSMOS 1423 1982-115A, 13685

Launched: 1400, 8 Dec 1982 from Plesetsk by A-2-e.
Spacecraft data: Similar to the Molniya satellites.
Mission: Molniya-1 type communications satellite, the final rocket stage appears to have exploded on ignition.
Orbit: (largest fragment) 231 X 425 km, 93.78 min, 62.83 degrees.

METEOR 2(9) 1982-116A, 13718

Launched: 2230, 14 Dec 1982 from Plesetsk by A-1.
Spacecraft data: Cylindrical body with two, Sun-seeking solar panels, length about 5m, diameter about 1.5m and mass around 2,200 kg.
Mission: Return of meteorological data and scanning radiometer images of cloud cover and Earth's surface.
Orbit: 810 X 859 km, 102.00 min, 81.25 degrees.

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BOOK NOTICES

JPL and the American Space Program
C.R. Koppes, Yale University Press, 299pp, 1983, £16.95.

The Jet Propulsion Laboratory in Pasadena, which may well rank as the world's premier space laboratory, has always played an extremely important role in the American missile and space programme.

It began in 1936 when an unlikely combination of Caltech graduate students and local enthusiasts banded together to build rockets. The group made some fundamental breakthroughs in both liquid and solid propellants, developed JATO rocket motors during WW2 and engineered sophisticated missiles subsequently. In fact, there is a case for advocating that American rocketry evolved not from the work of Robert Goddard or the V-2, but from JPL initiatives.

The Laboratory provided the first American satellite, Explorer 1. Ranger, supposed to view the Moon close up, suffered six straight failures for reasons as complex as managerial failures and as trivial as the accidental omission of a hyphen from a computer program, an error that caused the $25 million Mariner 1 mission to fail.

In recent years the planetary exploration programme developed by JPL has revolutionised our understanding of the Solar System. JPL was responsible for the ten Mariner missions from 1962–1974 which sent American spacecraft to Mercury, Venus and Mars, and for the Viking missions to Mars in 1976. In a stunning climax, the Voyager missions returned outstanding photographs of Jupiter and Saturn before one of them ventured on to Uranus and Neptune.

This story of JPL is, however, rather more than a technical or scientific history. It embraces political controversies and human interactions, the frequently acrimonious relationship between JPL and its parent, Caltech, the US Government and aerospace industry and, ultimately, raises important questions about funding, control and even the purposes of such research.

Readers of *Spaceflight*, particularly, who are kept aware of some of the current developments at JPL in these pages through the contributions of Bill McLaughlin will know only too well the many exciting ideas which it continues to produce. This volume will prove a wonderful companion. It will provide the historical background so necessary to deriving the greatest possible benefit from Bill's contributions.

The Super-Intelligent Machine
A. Berry, Jonathan Cape, 182pp, 1982, £7.95.

Practically everyone wonders if the sophisticated machines of today might be developed, eventually, into intelligent or even super-intelligent machines. An old adage says that Logic is the art of Reasoning, the implication being that reasoning is the application of intelligence. However, the robot-like machinery of today certainly use logic circuits but this in no way presupposes intelligence.

Intense interest in this aspect of technological innovation began, innocently enough, when computers were developed to enable mathematical calculations to be made faster. This led to more sophisticated equipment making use of logic circuits, though still a far cry from anything which could be defined as artificial intelligence.

There is no doubt, however, that current trends are leading rapidly into the direction where electronic equipment, even on this basis, can so manipulate an enormous input of data as to be in a position to arrive at, and so initiate, decisions on topics which could only be arrived at by humans in the form of hunches or intuition.

Computers may, indeed, shortly be in a position to respond to the human voice and to distinguish one person from another but opinions differ greatly as to what lies beyond that point. Will the machine reach the intelligence of the average human being and educate itself to genius level, or will it remain, solely, the servant of Mankind, carrying out his bidding in accordance with instructions fed into it?

The present book explores all these, and many other, possibilities. It provides a clear and lucid position of the capacities of machines, how they function and how they may be developed, extending out to highly sophisticated equipment to explore the far reaches of our Galaxy free from all constraints apart from the initial instructions fed into it.

Whether such machines will remain servants or become masters the author leaves, largely, to the imaginations of his readers. They will, however, find this to be a most enthralling book which provides a basis of fact against which they can evaluate a multitude of exciting fictional accounts.

By Jupiter – Odysseys to a Giant
E. Burgess, Columbia University Press, 155pp, 1982, $32.50.

As the largest planet in our Solar System, Jupiter has long been of particular interest. This book, profusely illustrated with 130 photographs and drawings, surveys the history of our knowledge of Jupiter and describes the gradual, sometimes revolutionary, improvement in the information-gathering equipment used in unravelling its mysteries.

Particular attention is given to the results of the Jupiter probes, with emphasis on the sophisticated imaging equipment and other systems aboard the Pioneer 10 and 11 and Voyager 1 and 2 missions. The results of their discoveries, with photographs of the planet itself, its rings and satellites, are vividly described.

Introduction to Comets
J.C. Brandt & R.D. Chapman, Cambridge University Press, 246pp, 1982, £6.95 (Paperback).

On average, only one naked-eye comet appears each year though one normally has to arise before dawn to see it and, even then, it may appear no more than a misty cloud. This book traces the historical development of cometary studies from earliest beginnings to about the mid-twentieth century. In doing so, a description emerges of a comet as a unique celestial object, part of our Solar System and, perhaps at some stage in its existence, part of another star as well.

The physical processes by which comets interact with solar radiation is an area which will undoubtedly expand considerably if the space probes to Halley's Comet prove successful. Meanwhile, as the volume points out, discoveries are, even now, beginning to emerge e.g. the discovery of hydrogen clouds surrounding comets which was made by an instrument aboard an Earth-orbiting satellite.

The path to future studies was pointed out by the Skylab observations of Comet Kohoutek though, up to now, ground-based observations still form the core of cometary knowledge. There is no doubt that this is a situation which is about to be remedied but, in the meantime, this book is well worth reading as a very fine digest of the present state of play.

Some of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

The Realm of the Nebulae
E. Hubble, Yale University Press, 207pp, 1983, £25.00.

Before the 1920's no one knew for sure that there was such a thing as a realm of the Nebulae or, indeed, that there were other galaxies like our own. Of course, the idea of island universes was very old for Kant speculated on the subject in 1755. In the early years of this century, astronomical opinion was sharply divided on the issue. Were nebulae, indeed, island universes, or were they much nearer, members of our own system? In the midst of all this confusion, the late Edwin Hubble joined the astronomers at Mount Wilson Observatory with access to the great 100 inch reflector and, in the closing days of 1924, was able to announce his decisive discovery that there were Cepheid variables in the Andromeda Nebula. The controversy was over.

Hubble then continued to classify nebulae, refining his distance scale and announcing that there was a relationship between the velocity of recession of the nebulae and their distances.

The lectures from which this book was compiled were given 45 years ago, when astrophysics as we know it today was in its infancy. That makes it all the more amazing that one can read through these pages and find that the picture presented differs from today's only in matters of detail. In fact, a good deal of attention is still paid to questions Hubble asked, few of which have been answered in the intervening years.

Violent Phenomena in the Universe
Jayant V. Narlikar, Oxford University Press, 218pp, 1982, £9.95.

A striking discovery over the past few decades is that the Universe contains centres of violent activity. These pour out vast amounts of energy, some in regular cycles, some in gigantic bursts. What are the cosmic energy-sources responsible for these spectacularly violent events and did our Universe, itself, originate in a violent explosion? These are just a few of the subjects to which the author addresses himself in areas where excitement and controversy abound.

Problems range from objects which have been emitting radiation over millions of years to those which are active over a matter of a few seconds. Astrophysicists have been kept on their toes by such developments and have responded to the challenge of explaining such weird phenomena by constructing some very ingenious theories.

Accordingly, the author takes his readers through gravity according to Newton and Einstein, delves into black holes and then reverts to deal with stellar explosions and their aftermaths, eventually ending up with powerful X-ray sources and the so-called "active galaxies" i.e. those which emit jets or which are too close together for comfort.

In spite of the technical nature of the work, the book is so eminently readable that those not mathematically inclined can turn a blind eye to those parts of the text in which formulae appear.

Sky Atlas 2000.0
W. Tirion, Cambridge University Press, 1982, £15.00.

This is a large-format spiral-bound plastic-covered atlas containing 26 star charts covering both hemispheres. It represents the first comprehensive set of star charts for this new co-ordinate epoch.

It contains some 43,000 stars down to visual magnitude 8 and about 2,500 deep-sky objects, with the Milky Way shown in various colours according to the key appearing at the top of each chart.

Multiple and variable stars are clearly indicated, as are the constellation boundaries. Deep-sky objects are labelled by their NGC or IC numbers. Objects in the Messier catalogue are also indicated, while those which bear popular names, such as the Trifid Nebula, are indicated as such. The lettering and labelling provides a maximum of clarity.

The atlas contains four special inserts showing areas of particular interest in more detail. One of these is on the Pleiades, with another on the Orion Nebula.

Landolt-Bornstein Group VI, Vol 2, Astronomy & Astrophysics – Subvolume C
Springer-Verlag, 478pp, 1982, $312.

This new book completes the three sub-volumes which now make up volume 2 on the theme of astronomy and astrophysics. The two earlier volumes, dealing with the Solar System (6/2A) and stars and galaxies (6/2B) are extended now to include (6/2C) on interstellar matter, galaxies and the Universe.

As before, this volume provides a massive compendium of existing data on the topics chosen, extended by a series of selective references which, generally, will take the reader to the heart of any particular matter. The compilation of such a volume must have been extremely difficult with such a rapidly developing field.

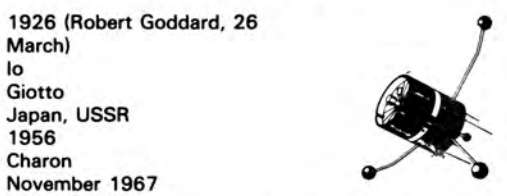
The largest part is concerned with galaxies and the Universe at large. There is probably enough material in this area alone to fill a number of sub-volumes in their own right. For this reason much of the data is of a general nature but extensive references to more detailed catalogues, atlases and similar material is provided.

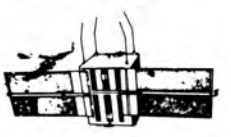
The opportunity has been taken to add an appendix on Halley's Comet. This includes orbital ephemerides for the 1986 return as well as a selection of orbital data on the returns of other periodic comets up to the year 2002.

A comprehensive index of all three sub-volumes is included.

Answers to quiz on p.187

1. 1926 (Robert Goddard, 26 March)
2. Io
3. Giotto
4. Japan, USSR
5. 1956
6. Charon
7. November 1967
8. Venera 9, 1975
9. 381 kg
10. July 1979
11. 94 in (239 cm)
12. Pioneer 10, 1973
13. Alexi Leonov
14. November 1982 (STS-5)
15. Mariner 10 (Venus & Mercury)
16. *Discovery, Atlantis*
17. Armstrong, Aldrin, Conrad, Bean, Shepard, Mitchell, Scott, Irwin, Young, Duke, Cernan, Schmitt





18. A large European experimental communications satellite
19. Centaur
20. Barnard's Star
21. 84
22. (a) Apollo 8, (b) Skylab 4
23. Landsat 4
24. 1966 (Gemini 8)
25. 16
26. 1968 (air crash)
27. Ganymede (diam. 5276 km)
28. (a) 1986; (b) 1989
29. Neptune (Pluto's eccentric orbit brings it closer than Neptune during 1979–1999)
30. French Earth resources satellite (for launch in 1984)

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NOTICES OF MEETINGS

Study Course Visit (Open to non-Course Members)

The final meeting in the Astronomical Study Course is an accompanied visit to the Royal Greenwich Observatory at Herstmonceux on **14 April 1983.** Arrival will be at 1.30 p.m. The tour will begin at 2.00 p.m. and last for about two and a half hours, followed by admission to a special exhibition. Arrival by train is not recommended as the nearest station is about five miles away. Further information is available from the Executive Secretary. (Please enclose a stamped addressed envelope).

Technical Forum

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **Friday, 3 June 1983**, 6.30–9.00 p.m., and **Saturday, 4 June 1983**, 10.00 a.m. to 12 noon and 1.30–3.30 p.m.

Topic: **THE SOVIET SPACE PROGRAMME**

It is anticipated that papers will be given at the Friday evening and Saturday afternoon sessions, with some Soviet space films being shown during the Saturday morning session.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society. Members with a special interest in the Soviet space programme are invited to attend. A registration fee of £3.00 is payable. Forms are available from the Executive Secretary on request, enclosing a stamped addressed envelope.

18th European Space Symposium

Theme: **SPACE PROGRAMMES FOR EUROPE**

To be held in the Society's Conference Room at 27/29 South Lambeth Road, London, SW8 1SZ on **8–9 June 1983.** Organised by the BIS and co-sponsored by the DGLR, AIDAA and AAS, with support from Eurospace. The number of participants will be limited to a maximum of 60, with priority to Speakers, Society Representatives and subject specialists.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society.

Programmes and Registration forms will be available in due course.

38th Annual General Meeting

The 38th Annual General Meeting of the Society will be held in the Lancaster Room, Caxton Hall, Caxton Street, London, SW1 on Saturday **24 September 1983,** commencing 3.00 p.m.

Details of the Agenda will appear in *Spaceflight* in due course.

Nominations are invited for election to the Council. Forms can be obtained from the Executive Secretary. These should be completed and returned not later than **1 July 1983.**

Should the number of nominations exceed the number of vacanies, election will be by postal ballot. Voting papers will then be prepared and circulated to all members.

34th IAF Congress

The 34th Congress of the International Astronautical Federation will be held in Budapest, Hungary on **10–15 October 1983.**

Theme: **COOPERATION IN SPACE**

Members of the Society wishing to present papers are asked to notify Dr. L. R. Shepherd, Chairman of the BIS International Liason Committee at Society HQ as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

LIBRARY

We are seeking many technical books on astronomy, space research and space technology, and would welcome hearing from members with material they would like to donate to us to help fill the gaps.

The Library will be open to members from 5.30–7.00 p.m. on the following date:

3 June 1983

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

GIFTS AND DONATIONS TO THE SOCIETY

Most established learned bodies in the UK owe their prestige and affluence to Endowments and Gifts conferred in the past. These have enabled them to perform tasks, expand, build up valuable libraries and collections of paintings, seek prestige premises and undertake a multitude of projects which, cumulatively, established them in the shape of the major organisations they are today.

Members who might like to consider donating to the Society, eventually, some gift of books, paintings, money, etc. by making provision for it in their Wills are invited to discuss it, first of all, with the Executive Secretary, who can supply some explanatory notes on the procedure to be adopted if necessary.

Gifts like this do not require making out a new will. An existing will can easily be altered to include the gift, simply by making out a Codicil. The Executive Secretary will explain this, too, if required.

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CONTENTS

242 **Europe in Space**
E. S. Mallet

249 **Milestones**

250 **Correspondence**

253 **Space Communications**

254 **Is Mankind Unique?**
A. R. Martin and A. Bond

257 **Personal Profile**
Frederic Taylor

260 **Space Report**

264 ***Challenger* Meets the Challenge**

266 **News from the Cape**
Gordon L. Harris

268 **Space at JPL**
Dr. W. I. McLaughlin

272 **Japan's Halley's Comet Probes**
Neil W. Davis

275 **John Young – One Man's Conquest of Space (Pt. 4)**
D. J. Shayler

277 **Satellites Saving Lives**
Dr. A. M. Choudbury

280 **Lightning Research from Space**
Joel W. Powell

284 **Satellite Digest – 164**
Robert D. Christy

288 **Book Notices**

GIVE US THE TOOLS . . .

We are doing all we can to raise £30,000 to equip the Society with a range of new electronic and mechanical equipment. This is vital to our future well-being. Practically all our equipment, after years of sterling service long exceeding its normal lifetime, is now obsolete and has to be phased out.

So far we have received £4,302. This is well below what we need but, as the need is urgent, the Council plans to renew equipment as funds come in without waiting for the total to be reached. We require a much-improved photocopier immediately, to be followed by a word processor as soon as funds allow. We also plan to add a Vivitar slide copier to help keep up the supply of illustrations for our magazine.

These items will fully exhaust monies received to date but the Council feel sure their members who have already contributed to our Appeal will be very satisfied to see their donations put to such good use.

The Council plan to use any further funds to improve our facilities for labelling and addressing circulars and magazines to members. We lag behind the times in this area and improvement is long overdue. But the major item will remain the acquisition of phototypesetting facilities. This, alone, could cost in the region of £20,000–30,000.

These matters are now so urgent that the Society has to make a big effort to try to secure all these improvements in the coming year.

Everything depends on receiving sufficient help from members so, if you can, please help us to move past yet another milestone in our aim to strengthen the Society in every possible way.

Apart from direct donations to the Appeal, members can help in many other ways. Completing a Deed of Covenant allows the Society to reclaim tax already paid – last year more than £2,300 came from this source. Payment of subscriptions by Direct Debit saves considerable time – and thereby expense – in processing payments each year. Both forms are simple to complete – why not write to the Executive Secretary now for them?

Acquiring new members is a vital task if we are to expand. If each existing member strove to introduce someone new to the Society we would be well on the way to our target. BIS literature and magazines are available for display at courses, lectures, exhibitions, etc., and available on application to the Executive Secretary. Please give full details of the particular event as well as your estimated requirements.

COVER

The Manned Maneuvering Unit will allow astronauts to move around outside the Shuttle Orbiter and its cargo bay. It will see its first space test during STS-11 next spring with astronauts Bruce McCandless and Robert Stewart operating it; George Nelson will use it on STS-13 to recover the ailing SMM solar observatory for on-the-spot repairs.

Martin Marrietta Aerospace

В журнале не печатается ряд страниц.

EUROPE IN SPACE*

By Edmund S. Mallett†

Introduction

The tenor of this paper is to look ahead at the European Space Agency's aims and ambitions. We should remember that our scientific founding fathers in the early 1960's envisaged an "independent, permanent commission" – the CERN of the space world – and so ESRO (European Space Research Organisation) was born and flourished. Buoyed up by enthusiasm and drive no-one worried too much about "fair return" as the first European satellites were built and launched. Fortunately, ESRO had from the beginning worked on the concept of a central design authority, rather than parcelling out work on a national basis. The results of trying to operate the latter method were reflected in the technical frustrations and eventual demise of ELDO (European Launcher Development Organisation).

The ESRO/ESA scientific satellites have enjoyed enormously successful careers. The quantity of data returned from them is an embarrassment of riches to several space science communities.

At the same time, the success of the early ESRO satellites had perhaps brought about more political awareness of the potential applications of space and, allied to the success in the USA of INTELSAT, the lobbies for taking Europe into the applications fields were gathering strength. With the advent of such satellites the idea of ESA as the *only* focus for European endeavours in the peaceful use of space lost ground.

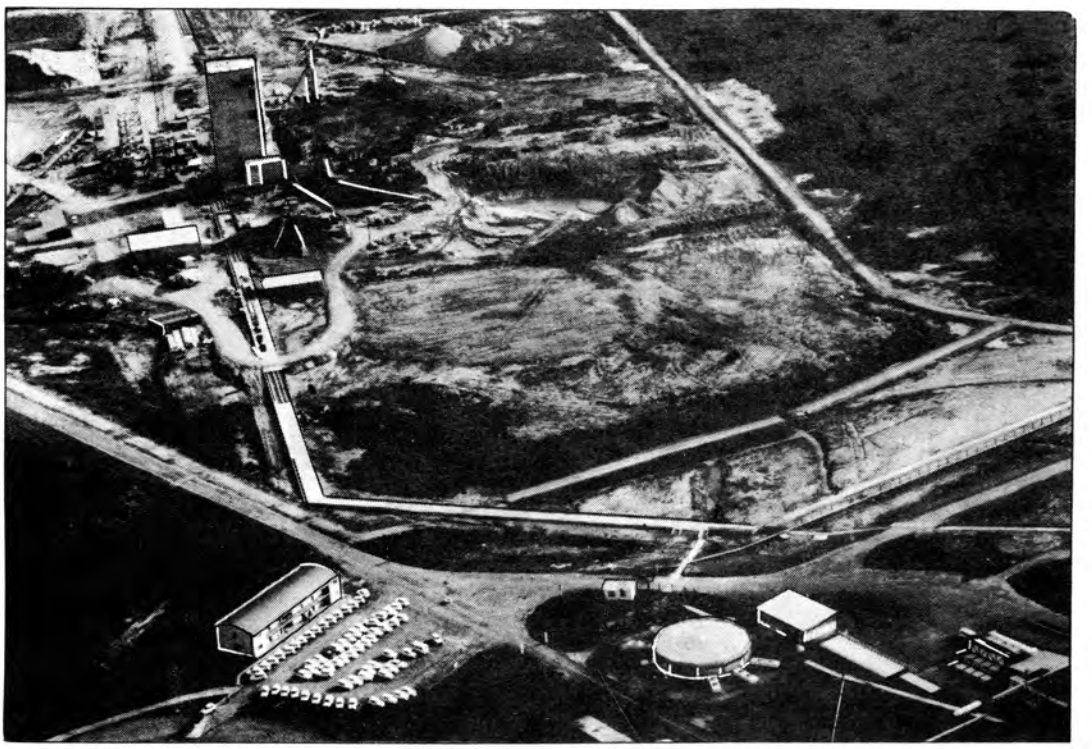
Several reasons can be given for this change of emphasis. Applications satellites need users, and for telecommunications and meteorological satellite systems the main users are government owned or controlled. They have strong international interfaces, but retain even stronger national tendencies and loyalties. Politicians in their attempts to control the economic environment must satisfy electorates which are not yet ready to discard national aspirations to be part of "Europe." The national industrial lobbies also play an aggressive role as they can see an era approaching in which the leaders in space technology can reap a decided advantage and profits in future markets, including the technological spin-off into non-space applications.

Finally, the interests of ESA member states do not coincide in two respects. Europe is not yet at a stage where one country will willingly allow another the monopoly of a particular specialised technology; and the extent to which each country feels it will benefit from a particular application varies greatly. In times of recession this is particularly true.

Only by offering member states the opportunity to take part in, or to stay out of, optional programmes, has it been possible to keep the European concept alive.

Now, though, there are signs of optimism. Norway and Austria have become ESA associate members, and there is a special agreement which Canada which augurs well for new incentives and drives in space.

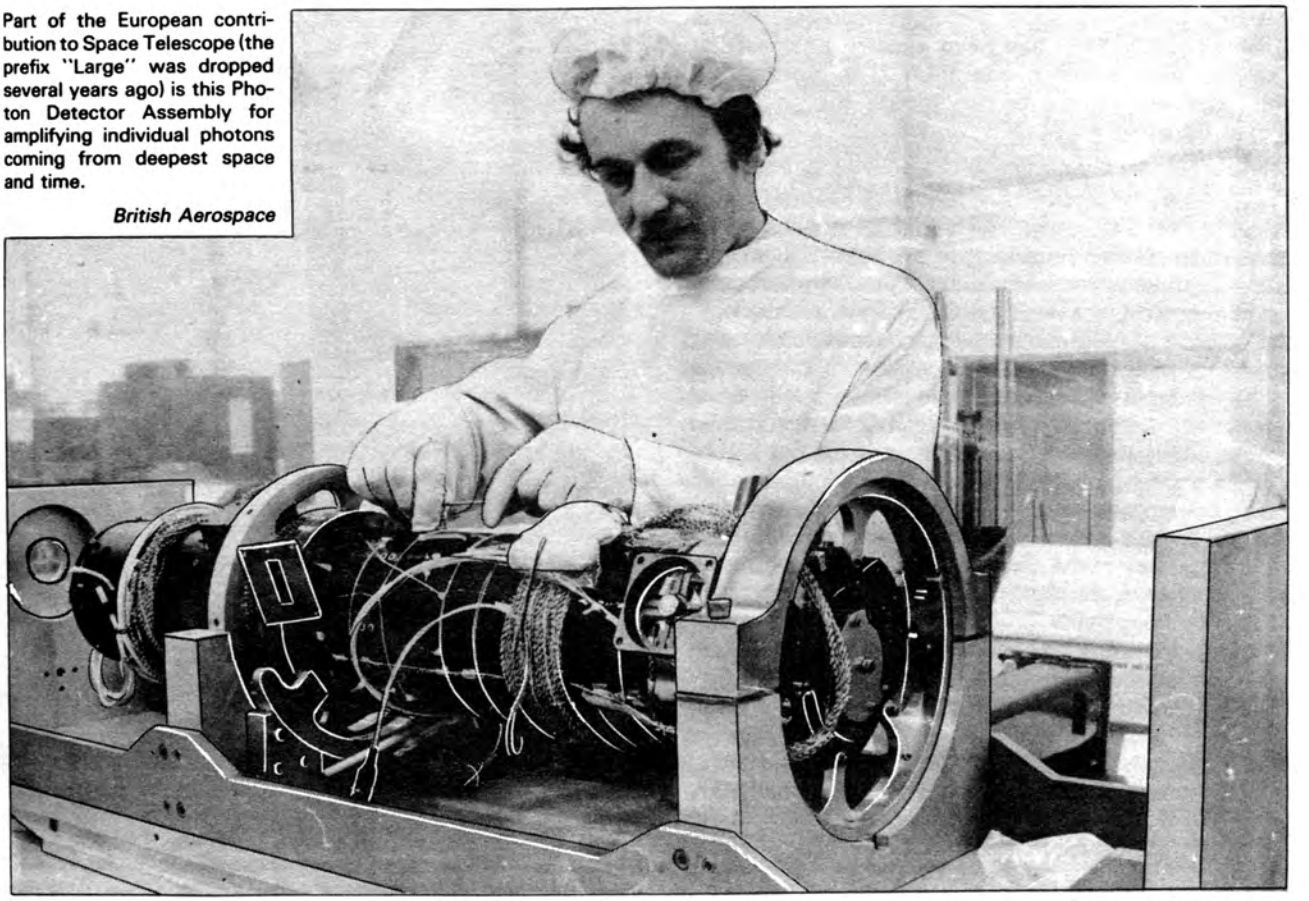
* *Presented at the Society's Space '82 conference in Brighton, 12–14 November 1982.*



Work in progress on the second Ariane launch site, ELA-2, at Kourou in South America for a first launch in 1985.

ESTEC

† *Mr. Mallet is ESA's Director of Applications Programmes.*



Part of the European contribution to Space Telescope (the prefix "Large" was dropped several years ago) is this Photon Detector Assembly for amplifying individual photons coming from deepest space and time.

British Aerospace

For those who feel that someone got his geography wrong with Canada, one can only say that Canada's identification with, and sympathy for, European space endeavours is most welcome. Nor is the "new company" confined to countries. The success of the Shuttle and the potential of Spacelab has stirred fresh interest among life and material scientists so that new communities are coming forward to seek ESA's help.

One sees that countries which have stood out against joining certain technology programmes are now reconsidering the cost in terms of lost technological transfer and markets. One suspects that industry has had a hand in pushing governments to a greater acceptance of co-operation.

The decision of the ESA Council to give the Agency a definite programme for the 1980's, *albeit* more limited than we would like, is heartening. Which leads us to a look at the future ESA programmes.

Ariane

It would be too much of a play on words to suggest that Ariane has had its "ups" and "downs." The early days of a launcher will always be difficult, and failures highlighted, but there is full confidence in the long term future of Ariane.

ESA remains responsible for the R&D element of the future European Launcher Programme in the sense that the ESA Council decided to undertake a follow-on programme to produce two upgraded versions: Ariane 2 and Ariane 3. The two are of similar design, but Ariane 3 will be fitted with additional boosters. This will give Ariane 2 the capability to place a payload in excess of 2,000 kg into geosynchronous transfer orbit, and Ariane 3 will take more than 2,400 kg – or two payloads of 1,140 kg – in a dual launch. Once the launchers have been proved in flight tests, the responsibility for production models passes to Arianespace and becomes essentially a commercial operation.

Deciding on future generations of launchers requires a crystal ball, in the sense that one needs to assess the requirements of satellite builders and users in the late 1980's and early 1990's. The expectation of the size and scope of geostationary satellites has led ESA to tailor Ariane 4 to allow Europe to offer a highly competitive launch system throughout the 1986–92 period.

Ariane 4 will be a versatile launch system capable of putting any payload weighing between 2 and 4.3 tonnes into transfer orbit, by using various combinations of liquid or solid propellant boosters. A demonstration firing is planned for the end 1985 or early 1986. The cost of placing a kilogramme of payload in orbit is expected to be only 40% of that of Ariane 1.

Another milestone in the long term could result from studies of an even higher performance launcher, which would be available from 1990 onwards; this new version should ensure a further cost reduction.

To enhance the operational flexibility of the launch

facilities and provide redundancy for the present Ariane launch site (ELA-1), it has been decided to construct a second Ariane launch site (ELA-2) in Kourou. By 1985, this will reduce to one month the necessary interval between successive launches of the various uprated versions of Ariane. ELA-2 is also necessary for the operation of the Ariane 4 programme.

Manned European Flight

The arguments for and against European participation in manned flight waxed strong before the decision was made to build Spacelab, and have continued during the development stage. One suspects that they will still be voiced after the first flights this year. The initial success of the Shuttle, and the less publicly acclaimed success of the first Spacelab element – the pallet – to fly, is heartening.

In operation, Spacelab – both the pressurised module and the pallet – will be transported to and from orbit in the cargo bay of the Shuttle Orbiter, and will remain there throughout the flight. Spacelab therefore extends the Shuttle's capability, and the Orbiter/Spacelab combination constitutes a space station which can remain in orbit for about seven days. This "space station" will provide opportunities for experimenters to live and work in space under conditions that are little more exacting than those experienced on Earth. Furthermore, Spacelab can be reconfigured after each flight to satisfy the needs of the next mission. Considerable flexibility in configuration and mission structuring is available to the user.

Only after two or three flights will we have assessed the full implications of Spacelab and its potential uses, especially the extent to which it can be used for the manufacture of prototype commercial products impossible to produce on Earth. These include alloys and composite materials with new properties, crystals of improved characteristics for the electronic components industry, high quality glasses for the optical industry, improved vaccines and biological products.

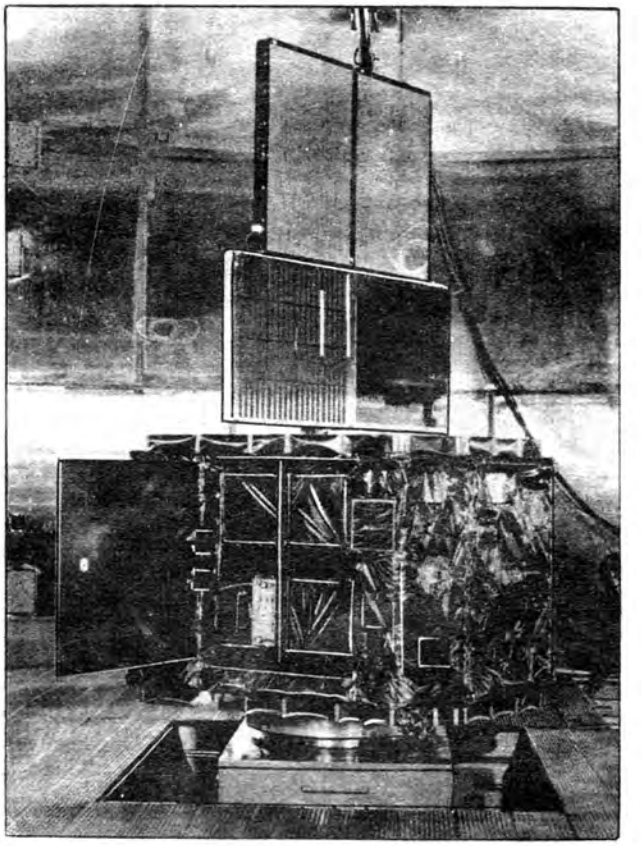
Apart from improving the existing model to increase time in orbit, experiment capacity and power, Europe is looking ahead to an era when the Shuttle will be used as a means of taking free-flying payloads into space, and retrieving them later. With this in mind, studies are well advanced into various configurations for Eureca: the European Retrievable Carrier. The cry of "Eureca" is attributed to Archimedes when he found a means of determining the purity of gold. Naturally we hope Europe will find gold in its advanced ideas for such space platforms.

Other Projects

I have already mentioned our past successes in the scientific field. Briefly, ESA has five scientific projects in various stages of development:

Exosat will determine the positions and examine the structures of celestial X-ray sources. It will use lunar occultation as well as other observation methods. The satellite is ready and awaits a suitable launch window.

Space Telescope: this 2.4 m telescope will dominate astronomical research for the rest of the century, contributing appreciably to our understanding of the geometry of the Universe. Europe is providing about 15% of the total cost: the Faint-Object Camera, its associated detector and the solar array. In return we will have 15% of the observing time of the telescope which is due to operate for at least 10 years.



Exosat, designed to make a survey of X-ray sources, should have been launched last November by Ariane but the Ariane L5 failure in September forced a postponement. It will now be orbited by a US Delta 3914 rocket from California. This is an engineering model under test at ESTEC in Noordwijk.

ESTEC

The International Solar-Polar Mission (ISPM) has been dogged by ill-fortune. The original idea to send two satellites out of the ecliptic plane with the help of Jupiter's gravitational field to fly over the Sun's north and south poles had to be abandoned when the NASA spacecraft was a victim of the budgetary cuts. ESA kept faith with the scientific community but the indecision over the development of an interim upper stage, by means of which the satellite will be launched into an Earth-Jupiter transfer orbit from the Shuttle, has delayed the launch still further.

Giotto has captured the imagination of the world; laymen and scientists alike can appreciate that a "once-only" mission of this nature needs very precise planning and not a little good fortune to succeed. The satellite will be launched in July 1985, and should encounter Halley's Comet in March 1986, one month after perihelion when the comet is at its most active.

Finally, **Hipparcos** will measure the five main astrometric parameters of distance, position and proper motions of about 100,000 selected stars.

Looking ahead, a number of possible missions for the 1990's are in their assessment stage. The Science Programme Committee of ESA will be meeting early in 1983 to select a mission. As always, financial restrictions will play a too-prominent part in the selection process.

It is sometimes forgotten that anything between five years and a decade can pass between the inception of a mission and the analysis of the returning data. With so many disciplines within the umbrella term of "Space Science", it is an almost impossible task to meet all of our wishes within ESA's financial limitations.

The Shuttle and Spacelab have opened up space to European life and material scientists in a way not hitherto available: we already have SLED, Biorack, and the material-science double rack ready to fly.

Earth Observations

From the time the first Meteosat pictures of Earth were shown on television screens, it has been clear that application satellite systems would be both politically and industrially important. There was bound to be a period of adjustment and assessment during which governments, users and ESA sorted out their respective roles. As so often happens, the technology was in advance of the demands placed on it, but user communities are now understanding more fully how to use existing systems and how to play a role in guiding future developments towards their goals.

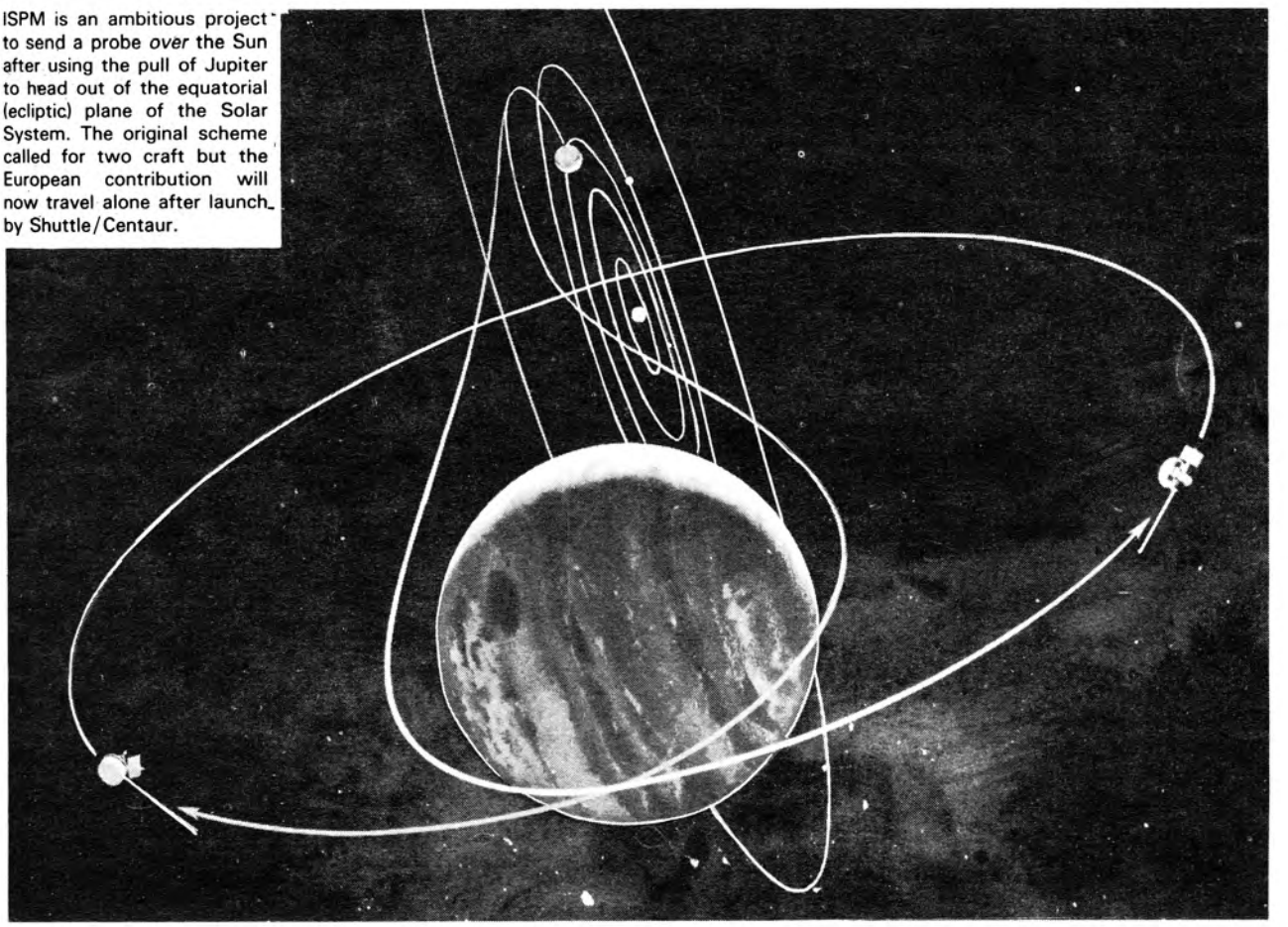
The users can equally see the necessity to "go European", and to be represented by a single voice when talking with ESA and other international or national authorities.

At present the meteorologists, having several years experience of using Meteosat satellites for image production, and as an integral and very essential element in the data collection and dissemination system, have advocated the formation of EUMETSAT which would be responsible for the control of an operational Meteosat system, and also act as the "customer" in discussions with ESA on what they expect from future generations of meteorological satellites. EUMETSAT still needs ratification at national parliamentary level, but all the signs are encouraging.

The Earthnet Programme has been set up to assist in the establishment of a well structured remote sensing user community in Europe and to build up the necessary expertise inside the Agency in preparation for the European remote sensing satellite programme. The terms of reference of the programme include the acquisition, archiving, preprocessing and distribution of satellite remote-sensing data.

For the present, Earthnet activities are centred around the acquisition and pre-processing of data from US satellites and some non-satellite campaigns. Plans are progressing for involvement on a wider scale including the Japanese MOS and LOS, the French SPOT satellites and the remote sensing instruments integrated in the First Spacelab Payload.

It is no secret that remote sensing is one of the



ISPM is an ambitious project to send a probe *over* the Sun after using the pull of Jupiter to head out of the equatorial (ecliptic) plane of the Solar System. The original scheme called for two craft but the European contribution will now travel alone after launch by Shuttle/Centaur.

subjects on which there was for some time a lack of agreement in Europe. France decided to carry out its own programme, and the SPOT satellite is due for launch in 1984.

After much heart-searching, the ESA Council decided that there should be a European remote sensing programme and that the first satellite, ERS-1, should prepare the scientific background for marine applications and ice monitoring. The payload of this 1987 satellite will include:

C-band active microwave instrumentation (AMI) combining the functions of a synthetic aperture radar, (SAR) a wave scatterometer and a wind scatterometer, and providing, respectively, high-resolution all-weather imaging (up to 30 m), wave-spectrum measurements and wind-field measurements;

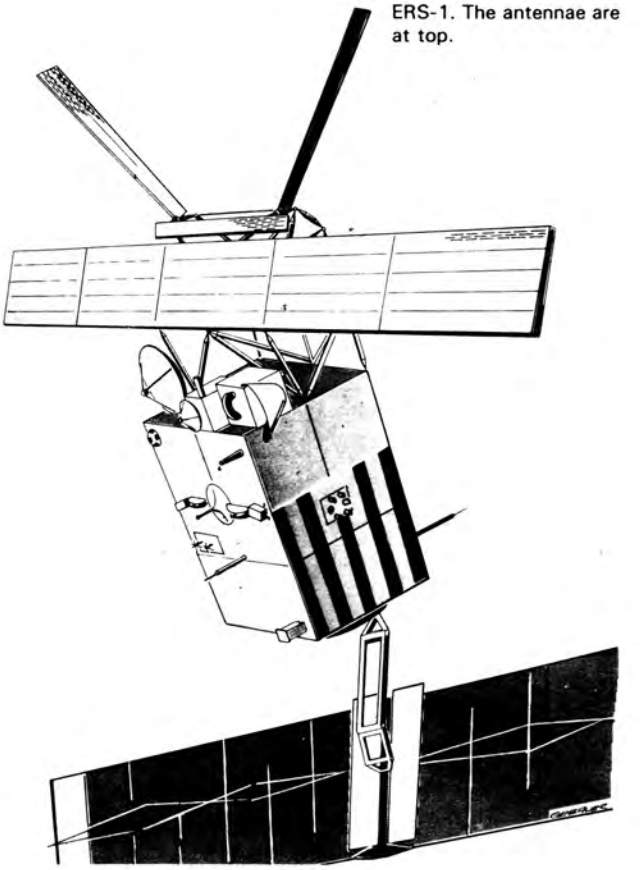
a radar altimeter, primarily for the measurement of significant wave heights and major currents.

In addition, a scientific package might be incorporated, subject to satisfactory responses to an "Announcement of Opportunity" which has been issued within the European scientific community.

That the European spirit can still prevail is evidenced by the complementary nature of ERS-1 (marine and ice applications) and SPOT (land applications).

Looking ahead, studies are envisaged on an advanced satellite for land applications, the payload consisting of an all-weather high-resolution (up to 30 m) microwave instrument, a SAR, and a high-resolution (30 m) multichannel optical instrument operating in the visible and infrared.

As a corollary, ESA, together with the Council of Europe and the EEC, has done much to foster investigations into the use of remote sensing satellites for, or by, developing countries. There are major opportunities not only for stronger ties between Europe and the developing countries, but also for European industry to stake a claim in new potential markets.



ERS-1. The antennae are at top.

The ECS-1 communication satellite is due for launch by Ariane L6 in June.

MATRA

Communications

The advantages of a European Agency being able to do business with other international organisations was well illustrated when INMARSAT undertook to use Marecs satellites in its worldwide system.

The use of satellites for maritime telecommunications was expected to demonstrate a number of advantages over the HF/MF radio frequency bands already in use. In particular, telephone and telex connections would be possible on a direct-dial basis to the subscriber, with the high transmission quality associated with international connections. Such services were not available at anything approaching this quality at HF/MF frequencies, and congestion and the operating procedures imposed by working under difficult conditions were leading to considerable transmission delays. Waiting times with the new system will be reduced from several hours to a question of minutes, if not seconds.

The Marecs satellites, with a capacity of some 40 channels, permit operations with ship terminals with dish antennae of approximately 1 m diameter. Aside from the pure communications capability (fully maintainable during eclipse), a search-and-rescue feature on the satellite can relay messages to shore from vessels in distress using low-power buoys.

The loss of Marecs B in last September's Ariane

launch failure was a disappointment, but INMARSAT has shown its interest and belief in the European capability by asking for a replacement, to which ESA has agreed. There is also an interest in future generations of maritime satellites and an element of the future studies programme is committed to them; ESA has presented a possible scenario to INMARSAT.

It is my belief that much of the future lies in the demand for, and ever widening scope of, satellite telecommunication systems. The well documented success of ESA's Orbital Test Satellite (OTS) opened the eyes of the European post and telecommunications community and the European broadcasting authorities to the possibilities of satellite systems. Of course, industry and governments had seen this too, and certain countries had decided on bilateral or unilateral programmes. The Franco-German Symphonie satellites have been used for a number of years, and France also has its internal Telecom-1 programme in the development stage. These two countries are also developing parallel direct TV satellites.

There is likely to be a proliferation of national communication satellite systems into the 1990's. This is not viewed as a threat to ESA's work. Rather, it reinforces the need for ESA's role as the centre of European R&D, and as a means of ensuring that European industry is competitive in a widening market. Several countries have already called on ESA expertise to help develop their national systems.

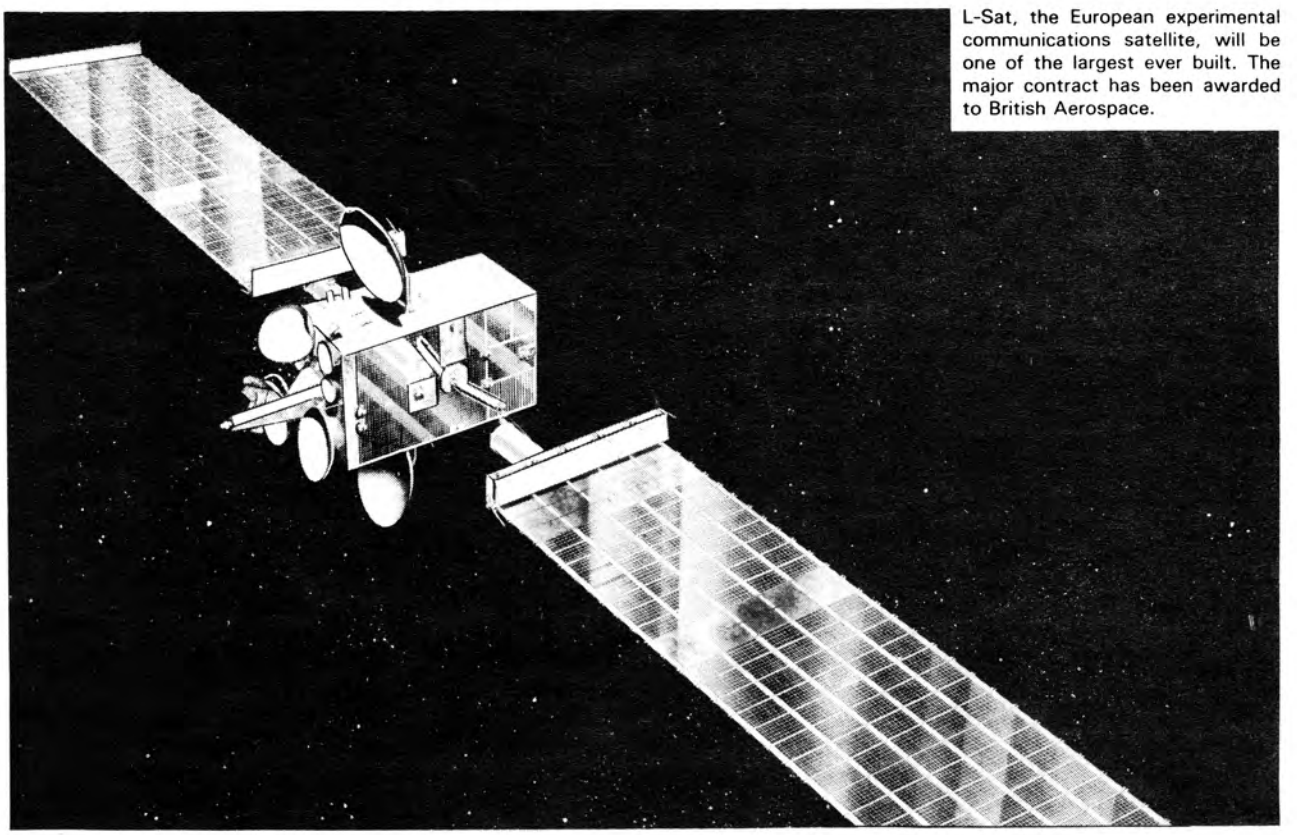
Meanwhile we await the launch of ECS-1 by Ariane, the first element in an operational European regional telecommunications system. The ECS series is ESA's second generation of point-to-point communications satellites. The repeaters of these satellites will be able to relay either telephony or television signals.

The ECS satellite, which is a development of OTS, is of the one-tonne class and will have a seven-year lifetime. It will provide services over an area similar to that of OTS, but with a combination of Eurobeam and multiple Spotbeam coverage. The greater prime power requirement compared with OTS leads to the use of a larger solar array. The satellite will have a capacity equivalent to 15,000 telephone channels as well as two TV channels and will, like OTS, operate in the 11/14 GHz frequency bands. It will operate with a network of perhaps 20 ground stations, each with an antenna of between 14 and 18 m diameter.

From ECS-2 "multiservices" will be included. These can be defined as all the non-PTT services, and for ECS-2 are geared to the growing demand for high-speed, heavy bulk data transmission and programme transfer. Multinational business concerns are interested in such services for file transfers, high-speed facsimile and video service, including video-teleconference facilities.

The major customers for telecommunications satellites in Europe, the PTTs created Interim EUTELSAT to act as their "single customer voice", and also to manage the European satellite telecommunications services, being responsible for their exploitation, and for relations with users. Under the terms of a contract concluded between ESA and EUTELSAT, ESA will provide two satellites in orbit for a period of ten years.

Some countries which had not made provision for bilateral or unilateral telecommunication satellites decided to take the initiative in a much more advanced



L-Sat, the European experimental communications satellite, will be one of the largest ever built. The major contract has been awarded to British Aerospace.

concept under the umbrella of ESA by means of an optional programme. As a result, approval was given in 1981 for the start of the main development phase for the European Large Telecommunications Satellite (L-Sat) programme. In financial terms, this satellite programme is the Agency's largest. The satellite will match (in size, mass and electrical power) the largest such satellites so far developed anywhere.

The satellite platform design is one of the first in which the "driver" is not the first payload, but the full range of future payloads. It will be fully compatible with both Ariane and the Shuttle combined with various perigee stage options. A modular design has been selected, being more flexible and better suited to the accommodation of a wide variety of different and multiple payloads. It has the advantage of faster assembly, integration and testing by allowing parallel operations on the different modules. The platform has a long in-orbit lifetime and high reliability objectives to improve the operating economics of derived operational systems. This is achieved through a rigorous design development and test approach, involving redundancy, correct parts selection, and a rigorous qualification programme including extended lifetests of all critical components. Finally, emphasis has been put on a low recurring price, both through the design and the selection by price competition of the most attractive procurement sources at equipment level.

For the first demonstration flight four payloads are to be carried:

direct broadcast; in view of the strong market prospects and need to acquire and demonstrate certain new technologies to satisfy future requirements;

special or business services in the European zone, to develop new technologies relevant to the next generation (on board satellite switching and multi-beam antennae) and to demonstrate current and new applications;

beacon generators at 12, 20 and 30 GHz to support the collection of propagation data essential to the design of future systems operating in this band;

transparent 20/30 GHz transponders to demonstrate systems expected to operate in this band (including video-conference, where a strong market demand is anticipated) and to develop the necessary technological elements which will be needed as "building blocks" in more complex operational systems.

The industrial structure for the main development phase of the programme has now been finalised and some 40 industries from 12 countries will have responsibilities at subsystem or equipment level within this structure, with the UK providing the prime contractorship.

The Future

To conclude, I would like to take a look beyond the immediate evolution of today's satellites, and into the 1990's.

The evidence mounts that the geostationary orbit is becoming overcrowded in many areas. There is a limit to how many satellites can co-exist in GEO before it becomes completely full. This is one of the factors which is pushing us towards larger, multi-payload/multi-service satellites, rather than towards more, smaller, single mission satellites.

Although the market will continue for these types of satellites, ESA's studies have indicated that this trend will, in the early 1990's, also force the introduction of completely new types of space segment. Studies are defining the requirements, and hardware developments are being initiated with European industry to ensure that the technology will be available when it is needed.

Economic considerations mitigate against satellites which are built to serve demand levels expected at the end of their lives. There is therefore a need to develop systems which can "grow" in orbit as demand increases. One such is that of a "cluster." This consists of several co-operating satellites, located close enough together in geostationary orbit so that, from the standpoint of the beamwidth of a ground station antenna, they appear to be located at a single point. The beauty of this concept is that the "cluster" could begin as a single satellite, containing sufficient transponders to meet the traffic demand at the beginning of the mission, and could then be joined later by others as this demand grows. To make full use of such a system inter-satellite communication links would be needed, and the technology for this will soon be developed by European industry.

Further studies within ESA have shown that a definite economic gain may be possible if the satellites could be refuelled. This would require the ability not only to rendezvous, but also to dock a "tanker" satellite to a satellite already in geostationary orbit. Methods of achieving this in the most cost-effective manner are also now being studied.

Once one has the ability to dock, a second concept can then be envisaged which has distinct advantages over that of the cluster just described. This is the geostationary "platform" which again, as capacity demand increases, can grow with time.

One of several possible future concepts now under study by ESA is the "European Space Assembly System (ESAS)." Under this concept one would first launch a satellite having a large deployable solar array, whose power capability is sufficient to satisfy the demands of several payloads. Individual payloads, together with a general transfer orbit module with only a limited power generation capability, would then be launched as needed and docked to the "power satellite." The growth pattern can easily be visualised.

Some missions, and the economics of certain combinations of multi-mission payloads, dictate the use of one or two very large deployable antenna reflectors, the use of which can be shared by a multiplicity of payloads operating at different frequencies.

Trying to envisage and put into practice European ideas is far from easy. I hope, however, the above presents the optimistic view that there are those who do see a European dimension, and who intend to pursue the cause of European co-operation through a vigorous and forward-looking European Space Agency.

MILESTONES

February 1983

18 The final report on the loss of the two boosters from the fourth Shuttle flight in June 1982 concludes that faulty switches allowed the main parachutes to separate early. The switches, normally activated when the boosters hit the sea, appear to have been triggered by the shock of small charges separating the booster skirts.

25 *Challenger's* no. 2 main engine (2015) is discovered to have a hydrogen leak. It is removed on the 28th, the same day engine 3 is also found to be faulty in the same place. Cracks have appeared near where a sleeve is attached to prevent chafing on a line taking hydrogen to the igniter. These two engines are reattached on 1 & 3 March. Checks on all seven of this engine type so far produced show that five suffer from the problem. All three of the Orbiter's main engines are now removed. Further launch delays are inevitable.

28 ESA announces that it is switching the launch of its Exosat X-ray satellite from Ariane to the US Delta rocket on 26 May because of delays in the European launcher series. See "Space Report" for further details.

March 1983

2 Kosmos 1443 is launched at 0932 GMT to dock with Salyut 7 space station on the 4th. The module, similar to the Kosmos 1267 "Star" unit that spent a year attached to Salyut 6, will allow expanded manned operations, The next Soyuz launch window occurs in late April

14 NASA announces that there will be further STS-6 delays, Technicians have found that high winds on 28 February carried sand, salt and silicate particles into the cargo bay, possibly contaminating the TDRS satellite's solar panel hinges. Such material could prevent the panels unfolding in space. The satellite is removed and cleaned; on 21 March the launch is set for 4 April.

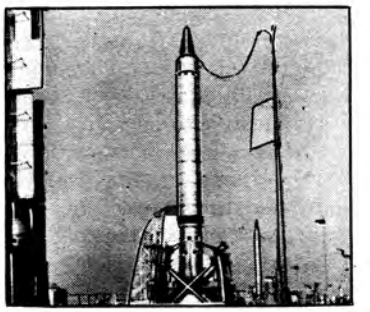
15 The Soviets launch a second 1000 kg winged spacecraft from Kapustin Yar. Kosmos 1445, like Kosmos 1374 of last June, is believed to be part of a development effort for a small shuttle. It is recovered from a 208 × 158 kg orbit after 1½ revolutions.

21 A 4% more powerful version of the shuttle booster is test fired. It will allow up to 1400 kg more payload to be carried; STS-8 will be the first to use it.

29 ESA selects ISO (Infrared Space Observatory) as its new science project for the early 1990's. ISO will observe specific objects located in the general survey of the present IRAS satellite.

DO YOU KNOW?

Can you identify the rocket pictured below? Note the slightly different version in the background to the right.



Answer: It is a British Black Knight vehicle of the late 1950's/early 1960's, used for testing missile reentry warheads. The background version appears to be carrying the inverted solid-propellant second stage, with its motor nozzle protruding at the top. This stage was used to ram the test warhead (contained in the conical section) back down into the atmosphere to increase the heating rates. There were plans to use Black Knight as a Blue Streak upper stage to form the Black Prince satellite launcher: the idea was dropped in 1960 (although Blue Streak went on to form the first stage of the international Europa vehicle, a precursor to Ariane). The vertical lines on the main tank (a dark line can be seen on the right hand side of the foreground vehicle) were of different colours; a colour code then identified each rocket.

DO YOU REMEMBER?

25 Years Ago . . .

20 May 1958. The USAF and the National Advisory Committee on Aeronautics (NASA's predecessor) sign an agreement covering the development of the Dyna Soar spacecraft, a precursor of the Space Shuttle.

20 Years Ago . . .

15–16 May 1963. Astronaut Gordon Cooper completes a 34 hr flight in his *Faith 7* Mercury capsule, the last of the series.

14 June 1963. Soviets launch Vostok 5 with cosmonaut Valeri Bykovsky, later joined by Valentina Tereshkova in Vostok 6. The 119 hr 6 min of his flight still stands as the solo space record.

15 Years Ago . . .

20 May 1968. NASA announces plans to send two Mariner probes to Mars in 1969 for close fly-bys (Mariners 6 & 7 proved to be highly successful).

10 Years Ago . . .

25 May 1973. Skylab 2 astronauts Conrad, Kerwin and Weitz are launched to repair the ailing space station.

4 June 1973. Novosti reports the end of Lunokhod 2's activities on the Moon. It had travelled 37 km since landing in January.

5 Years Ago . . .

22 May 1978. The Space Shuttle Main Engines successfully complete their first major test firing.

D. J. SHAYLER

OUT NOW – A NEW SOCIETY BOOK

THE EAGLE HAS WINGS

Following the success of the *Daedalus* final report and ***High Road to the Moon***, the Society is now publishing a third book.

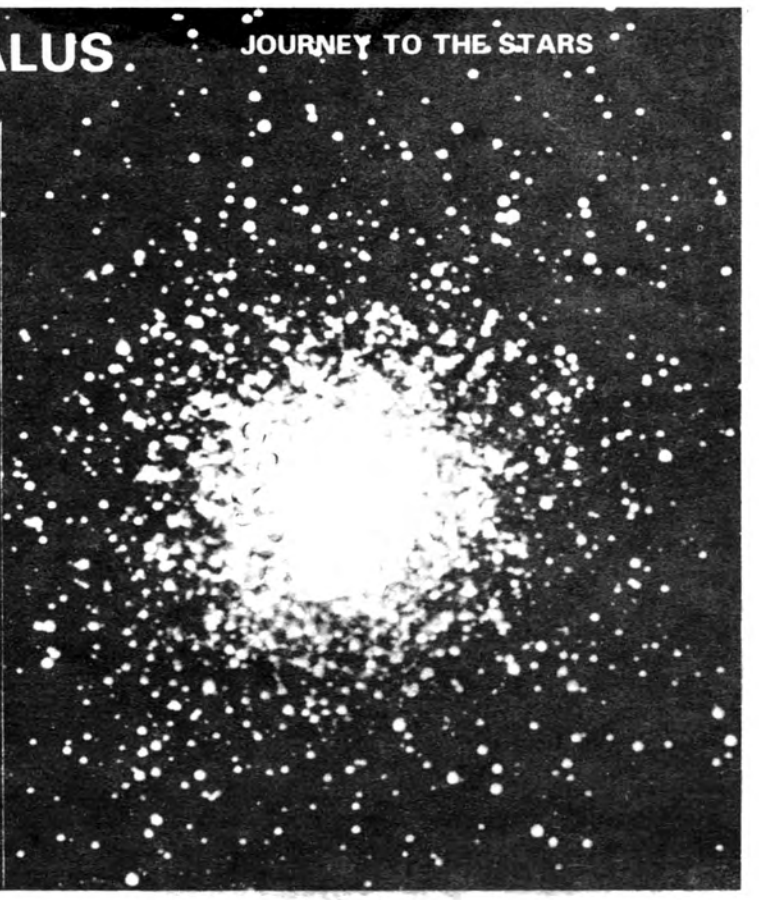
An exciting progression of space achievements in the years following the Second World War led to Man's first landing on the Moon in 1969. Rockets for probing the upper atmosphere evolved into the space launchers we know today. Vanguard, Explorer, Atlas, Titan, Mercury, Gemini, Apollo – a succession of names to conjure up memories of the 50's and 60's when man was taking his first tentative steps into outer space.

"The Eagle Has Wings" tells the story of the major US Space projects from 1945 to the watershed year of 1975, when the Apollo missions came to an end and the first wave of interplanetary exploration gave way to the more sophisticated probes of today. Written by *Spaceflight* managing editor Andrew Wilson, it is packed with information and photographs. It runs to no less than 144 large-format pages and can be obtained for the low price of £7 ($16.00) post free.

The book is available now. Be sure of your copy by sending for it now, to the British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

PROJECT DAEDALUS

JOURNEY TO THE STARS



The publication of the Project Daedalus Final Report marked the end of years of painstaking work by a group of BIS pioneers. The BIS received congratulations from around the world for its far-sighted project: designing a probe using reasonable technology for man's first crossing of interstellar space.

The Final Report contains 24 papers spread over 192 large-format (A4) pages, summarising the four year study. The papers cover the overall spacecraft design, mission profile, computer systems, navigation, experiments and our knowledge of nearby stellar systems, some of them possibly with planets.

"Daedalus" is acknowledged as a milestone in the development of advanced astronautics. Copies of the Report cost just £7.00 ($16.00) post free, from The Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ, England.

The Soviet Shuttle

Sir, There has been much talk in recent years about the development of a Soviet Space Shuttle vehicle. A recent publication (*K. E. Tsiolkovski i Nauchno-Technicheski Progress*, Nauka Publishers, 1982) contains an article by several Soviet engineers which describes the design and performance of the probable first serious study, a vehicle called "Albatross". The study was apparently concluded in the mid-1970's.

The vehicle would have a total weight of 1800 tonnes and consist of three sections: a fuel pod, a carrier jet and an orbital vehicle, the so-called "Raketoplan". The Orbital Jet would weigh some 1250 t and the Raketoplan, launched from the back of it, at about 60 km, some 320 t (238 t of propellant). The Raketoplan would be able to carry about 30 t to an altitude of about 220 km at an inclination of 45°. Maximum g-load experienced during the ascent would be about 3.5g. The landing weight would be about 82 t.

That the Soviets have chosen to release specific details about this study could indicate that they have decided upon another configuration.

NEVILLE KIDGER
W. Yorks

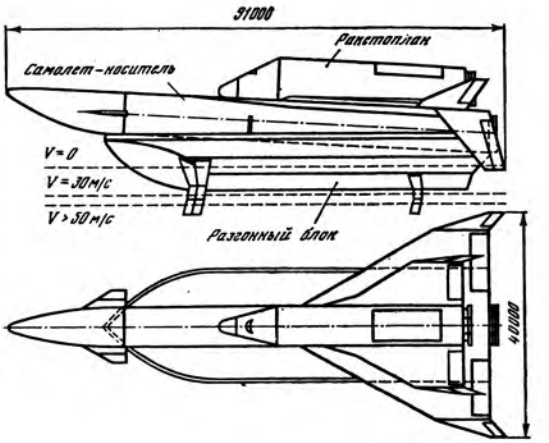
Lunar Orbiter

Sir, Does my memory deceive me: were Earth-based photograph's ever obtained of spacecraft in orbit around the Moon? I seem to recall that one of the Lunar Orbiters was captured in this way.

MAX WHOLEY

Your memory does you justice. We've managed to uncover this photograph taken by the 61 in. telescope at the University of Arizona of Lunar Orbiter 5 on 21 January 1968. The unmanned craft (the Lunar Orbiter

series was used to map most of the Moon in support of Apollo) was turned so that sunlight glinted off a set of mirrors; this 10-second exposure was part of a set of 52 showing the craft as a 12th magnitude object. LO-5 was deliberately crashed onto the Moon 10 days later.—Ed.



Into Space

Sir, Below is an unofficial forecast from NASA's Office of Space Flight in response to a query of mine of manned progress in space. NASA's official plans are for a low Earth orbit manned space station (1990) and a geosynchronous manned station by 2000. The first year figure gives the achievement date of an accelerated programme; that in brackets is for a medium-pace programme.

Permanent space station	1990 (1991)
First geostationary mission	1995 (1998)
Permanent geostationary station	2000 (2001)
Return to lunar orbit	2007 (2009)
Return to Moon's surface	2010 (2012)
Permanent lunar orbit station	2008 (2010)
Mars landing	2010 (2015)
Permanent lunar base	2016 (2020)
Permanent Mars base	2050 (2060)
Flight to Jupiter	2100 (2120)
Flight to Saturn	2120 (2140)

J. J. LATAPIE
Villelongue, France

Is the schedule optimistic or pessimistic? What do Spaceflight *readers think would be a reasonable plan of action?*—Ed.

A Fishy Story

Sir, Following my article on Japan's Halley's Comet probe [later in this issue—Ed.] in which I mentioned the rôle of fishermen in determining launch windows, I thought your readers might like to know a little more of this strange story.

Simply, launches from Japan's two southern space centres are subject to "fishermen-imposed" launch windows. The Japanese fishermen of the Kagoshima Prefecture area are quite powerful when it comes to the politics of determining schedules for rockets. For safety purposes, the fishing fleets around the Kagoshima area must evacuate the downrange paths just before major launches. Interruptions such as launch evacuations interfere with the important business of going out to catch fish, and the Japanese space programme must compensate the fishermen whose important business is affected merely because some

Correspondence /contd.

space specialists want to inject satellites into orbit.

The National Space Development Agency of Japan (NASDA) launches its N-series of boosters from the Tanegashima Space Center, 100 km south of the ISAS-Kagoshima Space Center (of the Institute of Space and Astronautical Science). The ISAS Center was built only after Dr. Hideo Itokawa received permission not only from fishermen but also chicken ranchers and cattlemen of the region! In operation since 1963, this site saw the first Asian satellite launch (February 1970); it is located 250 km southeast of Nagasaki. All rockets using these two independent sites must be launched during the stringent January-February or August-September time slots. These times are the worst fishing months, due to bad weather. Consequently, they are also the worst times to launch rockets, but the political power of the fishermen is highly influential in the Kasumigaseki district of Tokyo (the Whitehall of Japan). Typhoons often strike the two sites during August and September.

NASDA and ISAS space specialists treat fishermen with all due respect. In fact, ISAS rocketry expert Professor Hiroki Matsuo says that one of his most important jobs at the Uchinoura launch site is to be friendly toward the fishermen of the town, despite his uncommon distaste for fish!

Japan's first deep-space mission, the experimental Halley's Comet spacecraft "MS-T5" will be launched on 1 January 1985 (Japan Standard Time) from the ISAS-Kagoshima Center. Perhaps the local fishermen don't realise that, in Universal Time, the launch comes in the later hours of 31 December 1984. December launches are strictly prohibited without undergoing negotiations on compensation, so please refrain from telling any Kagoshima fishermen about the concept of Universal Time!

Fortunately, the launch window for the principal Japanese Halley's Comet spacecraft, Planet-A, fits into the aquatic window.

NEIL DAVIS
Japan

What's the Connection?

Sir, The photograph of the Hermes missile ("Do You Know?", March issue p.127) prompts a further question, based on the striking resemblance of the Hermes not so much to the V2 as to the V2-derived Wasserfall.

In "Atlas, the Story of a Missile", John L. Chapman recounts how the designers of the MX-774 experimental vehicle used the V2 fin shape in order to utilise captured German wind-tunnel data, only to learn afterwards that the fin shape was chosen to fit inside the standard German railway tunnel. Is there a similar story behind the resemblance of Hermes to Wasserfall, or is it just Wasserfall itself – i.e. captured German hardware?

I can't recall seeing the resemblance remarked on or explained, though it has intrigued me for many years, and I hope this is my chance to learn the answer.

DUNCAN LUNAN
Lanarkshire

The answer proved to be rather easy to track down. Mitchell Sharpe pointed out to us that the "International Missile and Spacecraft Guide" (Frederick Ordway and Ronald Wakeford, McGraw-Hill Book Co., 1960) says:

'Development of the Hermes A-1 surface-to-air missile was begun in 1946, and after a number of configurations had been studied, it was decided to base the program on the German Wasserfall."

Five A-1s were test flown from White Sands Proving Ground in New Mexico between May 1950 and April 1951. Other Hermes types covered solid-propellant, ramjet, gliding and long-range ballistic missiles, reaching various stages of design and testing by the General Electric Company under contract to the US Army.—Ed.

The Peenemünde Raid

Sir, In the review of Martin Middlebrook's book "The Peenemünde Raid", it is stated that this raid "turned out to be the only precision raid undertaken by the RAF by night during WW2" (February *Spaceflight*, p. 88). It is hard to imagine a more precise target than the dams in 617 Squadron's famous raid: not only more precise but far smaller than the Peenemünde complex. Furthermore, it is well known that the same squadron later carried out a large number of highly successful precision night attacks, notably on V1 storage sites. If the remark is meant to apply only to main force raids, there were a large number of precision attacks on marshalling yards, coastal gun sites, ammunition dumps and military camps before and after D-Day. In many cases the targets were smaller than the Peenemünde installation.

JOHN ALLISON
W. Midlands

The phrase in question was taken from the book cover itself. As we say on the book page (please note they are called "Book Notices" and not "Book Reviews"): "Some of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers . . ." -Ed.

SNIPPET

Here's to the Next Time . . .

Sir, I was very much impressed with the Space '82 meeting, the good attendance, the enthusiastic participants, and the well managed organization. You all should be congratulated. I'm sure your next celebration meeting will be even better, and I will try to attend.

Dr. P. A. PENZO
Jet Propulsion Laboratory
California, USA

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

UOSAT CALLING!

UOSAT, the spacecraft built at the University of Surrey and launched by NASA on 6 October 1981, began transmitting information in English this February by means of a speech synthesiser. It is the first time such a device has been used in a satellite. The transmissions can be received anywhere in the world by use of the simplest of amateur radio VHF equipment; even a hand-held "walkie-talkie" radio is adequate in suitable receiving conditions.

The synthesiser speaks in English with a mild American accent. Under the control of UOSAT's primary computer, it is giving operational telemetry information: the readings of 59 gauges and 45 switches, the equivalent of an aircraft's instrument display panel.

With the aid of calibration equations, anyone can listen in and find out, for example, the amount of solar particle radiation, the current being supplied by the solar cells, or the temperature in the batteries. The transmissions are presently on Saturdays and Sundays, primarily for the benefit of radio amateurs. They can be received on 145.825 MHz using any narrow-band VHF receiver. (Domestic VHF sets are not suitable.)

UOSAT's orbit passes over the poles, and in Britain during February it was above the horizon three or four times each afternoon (and during the early morning) at approximately 96 minute intervals, for periods of up to 12 minutes. Details of orbit times are given daily on Surrey University's UOSAT Information Service on Guildford (0483) 61202.

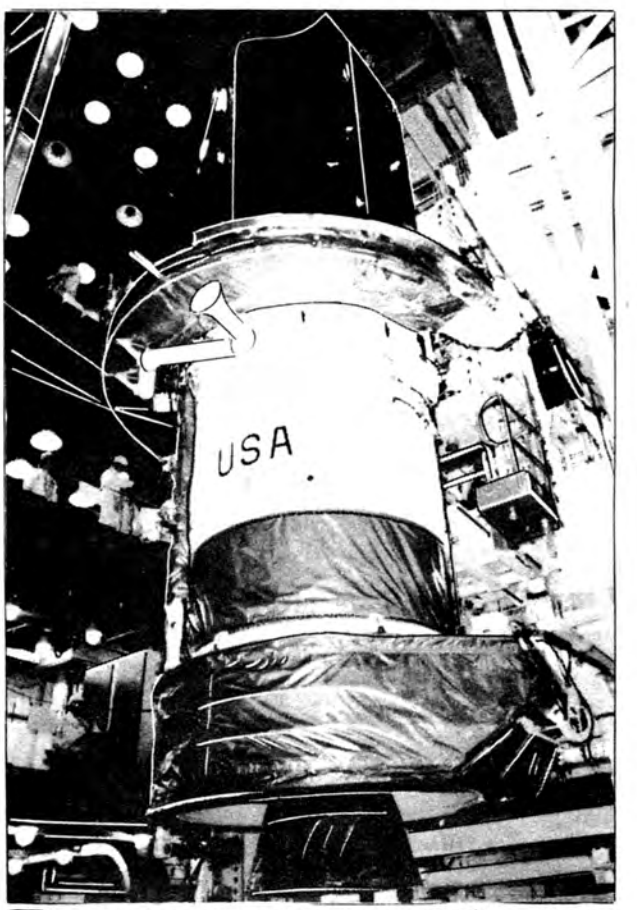
LEASAT SCHEDULE

As described in the Sep/Oct 1982 issue of *Spaceflight* (p.346), the US Navy's widebody Leasat communications satellites are being prepared for deployment from the Space Shuttle, writes Joel Powell. The first geostationary Leasat is scheduled for STS-14 (Spring 1984), followed by Leasat 2 on STS-18, Leasat 3 on STS-23, Leasat 4 on STS-30 and Leasat 5, the in-orbit spare, on STS-32 in 1985. All launches are slated for the *Columbia*, except Leasat 4 (*Challenger*). British Aerospace was recently awarded the contract for the launching cradle, similar to that for Intelsat VI which BAe is producing.

Leasat has an unusual method of reaching geostationary orbit. A perigee kick motor (a Minuteman missile solid third state) raises the transfer orbit to geostationary altitude, then a bi-propellant liquid apogee motor fires to circularise the orbit. Finally, a small hydrazine system finely adjusts the orbit and stops the drift.

IONOSPHERIC SATELLITE

A communications research satellite will be launched this June on a Scout rocket from Vandenberg AFB in California. The polar orbiting military satellite, designated HILAT, will carry out five experiments for the Defense Nuclear Agency to investigate the distortion of radio and radar signals travelling through "structured plasmas" in the ionosphere, writes Joel Powell. The payload consists of a radio beacon (signal scintillation), magnetometer (currents in the magnetic field), particle detector (electrons of 10–20 keV), ion drift meter (to determine the "electronic field") and a sophisticated auroral/ionospheric mapper to chart visible and ultraviolet aurorae. The satellite is a modified Transit navigation satellite bus, launched on a reimbursible basis by NASA.



The first Tracking and Data Relay System (TDRSS) satellite was launched aboard STS-6 in April. See the centre pages for further details. Here it is being raised on top of its IUS rocket stage for insertion.

NASA

T 14

IS MANKIND UNIQUE?

By Anthony R. Martin and Alan Bond*

The "Fermi Paradox" (if extraterrestrial intelligent beings exist elsewhere in the Galaxy, then we should see signs of them) has remained unresolved for over 35 years. This article presents some simple arguments which appear to rule out the possibility of a highly populated Galaxy, and which suggest instead that Mankind might be alone.

Anthony Martin (left) and Alan Bond (below).

Introduction

We want to discuss life in the Universe, and particularly in our Galaxy. We want to present some simple arguments, working from first principles, and draw some simple conclusions. None of our paper needs to be very complicated or sophisticated – and this is one of the important reasons why the ideas we are going to discuss need to be debated at greater length.

There is a view prevalent in the section of the scientific community that discusses such topics, especially among scientists in the United States, that goes something like this:

There are a lot of stars in our Galaxy, and around some of these stars a lot of planetary systems which include an Earth-like planet will have formed. On a lot of these Earth-like planets life will have started, and a lot of this life will have evolved over cosmic times to a level of intelligence. A lot of this intelligent life will be at a more advanced level than Mankind is, and they will be using radio waves to communicate and signal over long distances for long periods of time. The Galaxy is crowded with life of this sort, and all we have to do is to listen properly with our radio telescopes to tune in to their signals.

Enrico Fermi: "Where are They?"

We term this approach, Drake-Sagan chauvinism [1–3].

However, increasingly nowadays, a dissenting point of view is being voiced. This says:

OK, let us accept your statements about the frequency of the occurrence of intelligent life. But, as well as radio, a lot of these intelligent civilisations will develop interstellar travel. Anyway, even if only one did, the timescales to colonise the Galaxy, even travelling at small fractions of the speed of light, are much shorter than the age of the Galaxy. There should never have been a time when we were not aware of the presence of such a civilisation. We see no signs of this presence. You can't say that all these old, wise, powerful civilisations stay at home listening to their radios and never set out to journey among the stars. Therefore your initial suppositions must be wrong, and we are the first intelligence to arise in the Galaxy.

We term this approach, Hart-Viewing chauvinism [4–8].

This problem of reconciliation of two conflicting

**Presented at the Space '82 conference in Brighton, 12–14 November 1982.*

points of view was recognised 35 years ago by the Italian physicist Enrico Fermi, the man who constructed the first atomic fission "pile" in Chicago in 1942. The Paradox that carries Fermi's name is quite simple:

> If there are so many people out there,
> where are they?

Now, in the ten years or more that the authors have known each other, we have discussed this Paradox at great length, working our way steadily through every aspect of the arguments. We now feel that our thoughts and the justification for them are at a stage where we want to enter the debating arena.

We fly the standard of the Hart-Viewing chauvinists!

While working on Project Daedalus [9], it was made clear to us just how many areas connected with interstellar travel are actually quite pedestrian. The only really difficult bits to accept in Project Daedalus are the mining of Helium-3 from the atmosphere of Jupiter, and the need for a socially stable Solar System-wide civilisation to commit itself to the project. These requirements should surely be taken for granted if we are talking about the sort of ancient civilisations such as envisaged by the Drake-Sagan chauvinists.

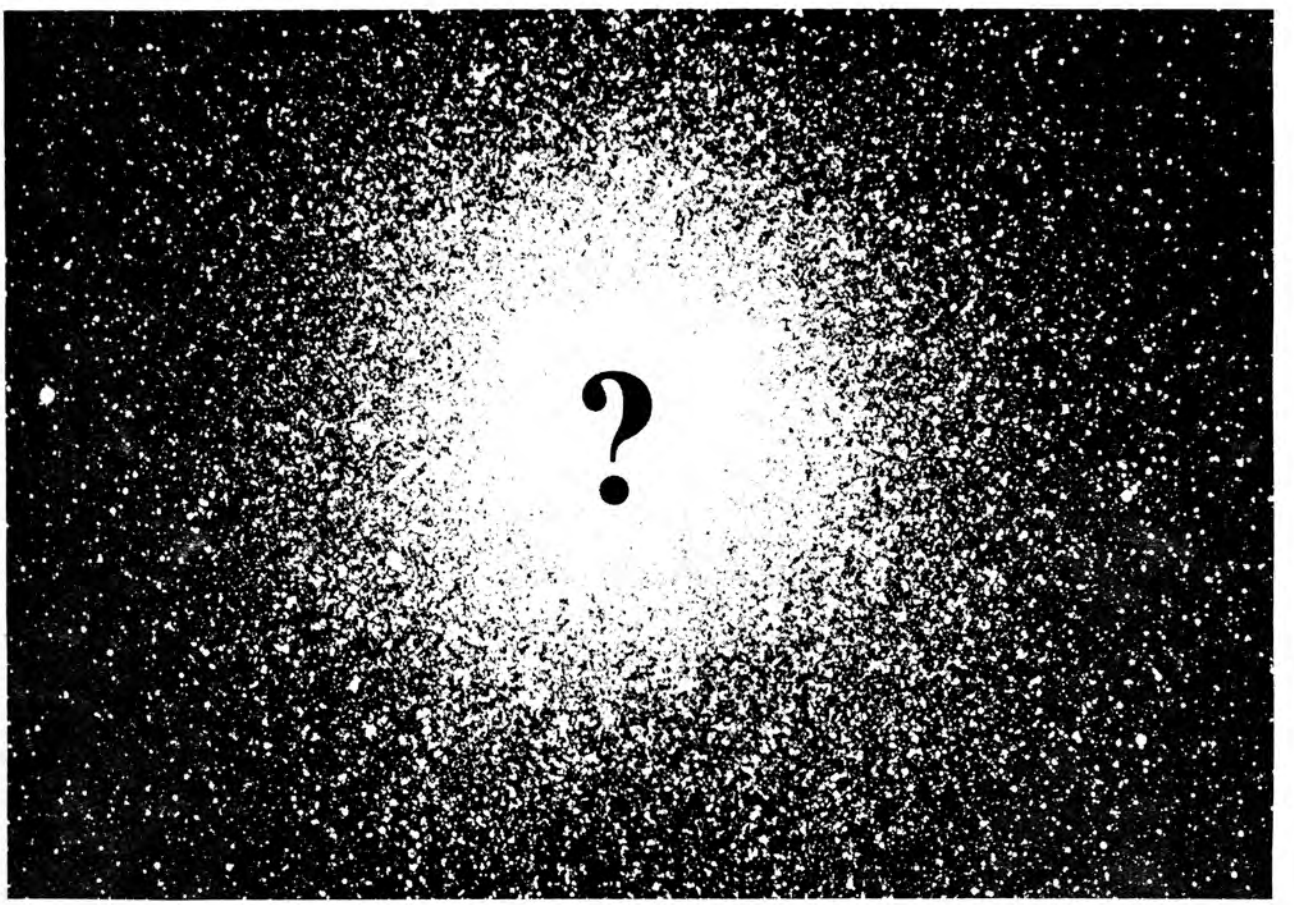
Further, we don't need to talk about speeds around 10 per cent of the speed of light, as in the case of Daedalus. The concept of a "world ship" – a vehicle that takes passage among the stars at a fraction of a per cent that of light, with many generations being born, living and dying onboard the ship – is now a firmly thought out and established concept [10, 11].

How long would it take for the ships of successive waves of colonisation, started by just one civilisation, to populate the Galaxy? Estimates vary remarkably little, in the range of 30–100 million years [12, 13]. The only dissenting number is that of the Drake-Sagan chauvinists [14], who arrive at a time of the order of the age of the Universe by use of, in our opinion, unnacceptably and fictiously small values for growth and emigration rates, and hence very, very slow colonisation rates. The correct situation was very aptly expressed by Viewing when he remarked that the Galaxy could be colonised in a time of the order of the age of the Earth at, literally, a walking pace!

Now, some people say at this point: Yes, of course you are right in all your suppositions except the last one – they are there but you have not looked for them properly.

Of course, no search for something the existence of which you are not sure about can ever be completed "Absence of evidence is not evidence of absence" is an oft-quoted saying in this topic. But, a lot of evidence of absence is a pretty good indicator as to where the correct answer may lie.

The Moon, on which the present scale of feature resolution is now metres, has been completely undisturbed for millions of years. Other moons and planets have been mapped and photographed at resolutions approaching tens of metres, also showing nothing artificial. Jupiter is by far the wealthiest place in the



Solar System – four spacecraft have flown close to that planet and not located a single worldship. Neither, it would appear, are there any near Saturn. There is no interplanetary communication between their vehicles within the usual radio frequency range, otherwise it would certainly have been detected.

Selective radio searches of specific stars within 80 light years have covered about 700 stars of similar characteristics to our Sun. The negative results of such searches do not place very restrictive limits on the possible number of advanced civilisations in the Galaxy. The situation changes, however, when we include non-selective, or all-sky, searches, where somewhere between 10 and 100 million stars have been covered. The negative results here limit the numbers to at most 50,000, and on more realistic, conservative estimates, at most 20,000 advanced communicative civilisations. This is still a large number, but the very limited radio searching possible to date has invalidated any ideas of a Galaxy teeming with millions of co-existing, communicating civilisations.

A major problem with the identification of phenomena observed at astronomical distances is to decide whether there are good grounds for assuming it to be due to extraterrestrial intelligence. We constantly discover new characteristics of astronomical objects, and these have always been explained on the grounds of natural phenomena. The detection of some simple property which could be explained by invoking astroengineering in one form or another is not, therefore, a sign of an advanced civilisation *per se*. Any new phenomena should be assumed to be natural and a natural explanation sought for its behaviour.

Still other people say, all this is not sufficient reason to assume that we are unique. Some of these civilisations may well stay at home, others may blow themselves up, others may not be interested in planets anymore after millenia in space, or their descendants many generations later may stagnate or decay, or we are in a sort of Galactic game reserve or zoo, or . . . the number of possible explanations is very large.

However, all of these explanations come up against the barrier of a very small number.

Hart pointed out the essential problem that no such resolution is sufficient to explain the absence of an advanced technical civilisation in the Solar System, unless we assume that the explanation will hold for every race of extra-terrestrials – regardless of its biological, psychological, social or political structure – and at every stage in their history after they achieve the capability of interstellar travel. If we are considering only a small number of cases this is not too serious, but it is not acceptable for the millions of civilisations assumed by the Drake-Sagan chauvinists.

So we are confronted by a very small probability that not even one of this supposed multitude of civilisations ever started colonising the Galaxy. And the probability is so small that it is very improbable indeed.

We said at the beginning that the fact that our arguments would be simple was important. They are so simple, that the resolution of Fermi's Paradox has apparently only one answer:

> They are not here, because they do not exist.
> We are unique in our Galaxy.

The ideas just outlined need to be discussed at much greater length, not just by scientists but by people of every discipline, because if we are unique, then we are the guardians of something very rare and very precious. We are the guardians of the most advanced, most evolved, most intelligent form of life in our Galaxy. And as guardians we must view our existence, and the possibilities of our extinction, in a whole new perspective.

Our position and responsibilities in the Universe take on a different meaning and we must not fail to justify the responsibilities that the laws of chance and evolution have placed upon our shoulders.

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In response to many demands, glass tankards of the type presented to the Speakers at Space '82 are being made available to members in a limited edition of 100. Orders (UK only – sorry but we can't run the risk of damage in sending abroad) should be *sent direct* (not to the Society) to:

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PERSONAL PROFILE

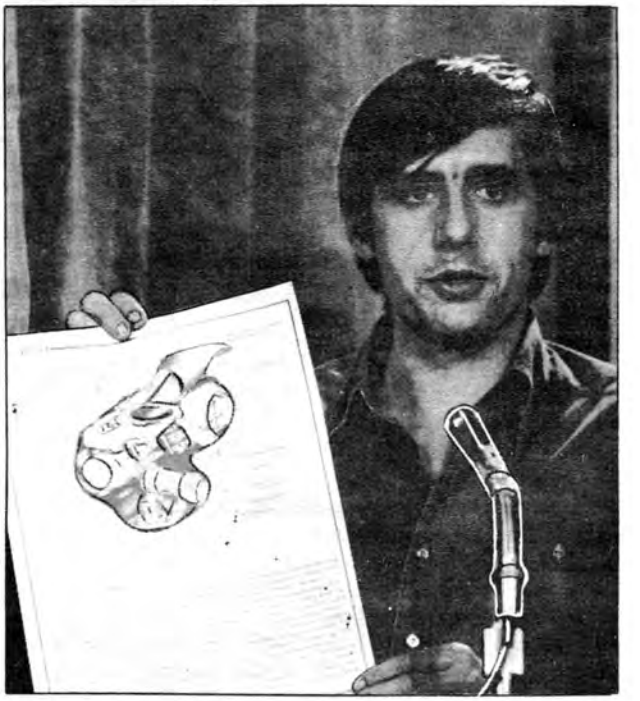
FREDRIC TAYLOR

All Aboard for Venus

In the beautiful Victorian city that Newcastle upon Tyne used to be, before the developers came with their motorways and concrete walls to improve it, almost everyone had an "allotment" of land somewhere on the outskirts of town where the council estates now rise. My grandfather's was not far from the banks of the Tyne, just the other side from the Felling, within walking distance of the big old house on the edge of Jesmond Dene. To see the house, you wouldn't have thought that my grandfather needed to grow his own vegetables, and he didn't; on his strip of land, among the potatoes and the leeks of lesser men, there rose the imposing dome of an astronomical telescope. It seemed vast to me, but even allowing for the perspective effect of short trousers, it left more of an impression than the mighty 200 inch of Palomar did years later, when I was living nearby in Pasadena and making my own telescope. Mine was even smaller than his – just a few inches. But mine was going to Venus.

If schoolboys, or girls, ask me now how they should go about getting into space research I tell them what my Headmaster told me – go for a good Physics or Mathematics degree first and specialise later. Degrees in rocketry or even, paradoxically, astronomy are fine but there will come a time later when you will wish your background was broader. Actually, I must admit that when I went up to Livepool in 1963 it was more the fact that Beatlemania had just broken out and the Northerner's fear of going any farther south that sent me there, rather than because, like most of the Northern universities, it had a good reputation in Physics. Three years later, thanks to luck, good teaching and a wise and sympathetic tutor who marched me around the pond to Greenbank for a couple of pints of draft Guinness the night before finals, ignoring my fraught gibberings about last minute revision of proofs and derivations I literally could recite while walking in my sleep (he had noticed I was starting to prove it), I had a First and I was on my way to Oxford. This move had very little to do with swapping the seaport for the dreaming spires; I love them both. All of the research at Liverpool then was nuclear physics; they did space research at Oxford. It may seem incongruous to find a group building satellite hardware on the same road where the little group of scholars, later to become the Royal Society, first used to meet, but once you are in the middle of it you soon realise that it feels right. The dreams and the schemes are all the same, just evolved in time a little. If you go to have a beer in the warm summer evenings in the garden of the Turf Tavern, you can end up leaning on the wall of the house where Halley lived. Just across the small town is George Hadley's college, St. Peter's; he was the first person to understand the circulation of the atmosphere of Venus, although he didn't realise it at the time. Now we are designing a mission to Venus, named after him, to explore the atmosphere in detail. Ghosts play a bigger role in science than most people realise.

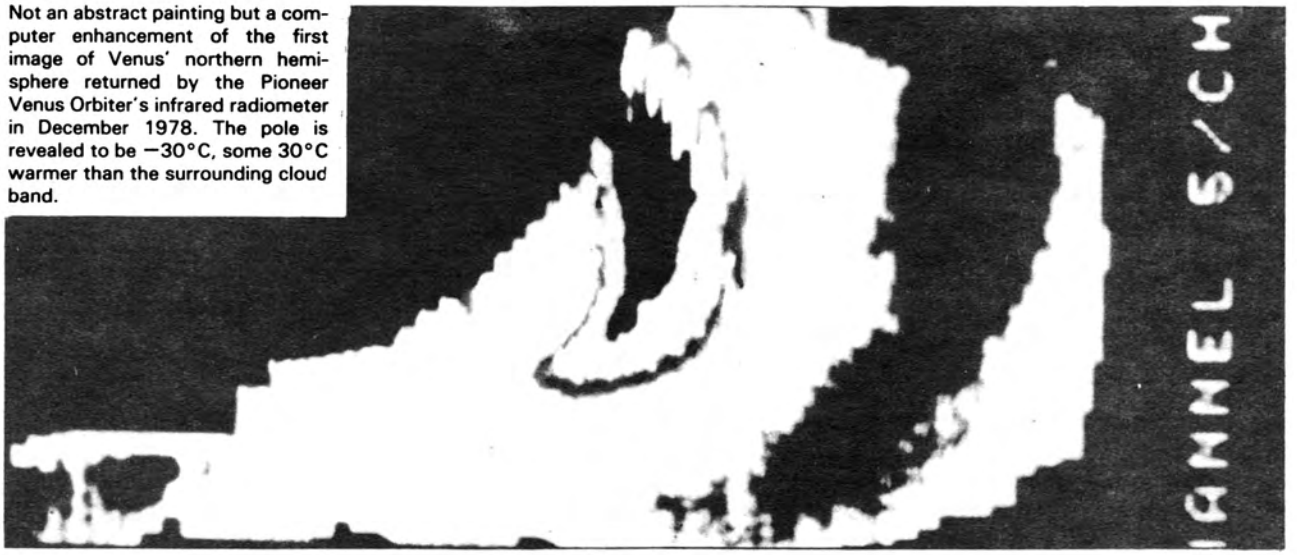
It was unusual in 1966, in fact to a lesser extent it still is, to find a British group making space instruments. In those days, Dr. (now Professor) Houghton of the Atmospheric Physics Department had just won space



Dr. Fredric Taylor, of the Dept. of Atmospheric Physics at Oxford University, unshaven and hollow-eyed after a sleepless night following Pioneer Venus Orbiter's arrival at Venus.

on one of the highly innovative American "Nimbus' series of experimental weather satellites for a new kind of infrared radiometer, jointly developed with Dr. S.D. Smith of nearby Reading University. The radiometer was to measure the vertical profile of temperature in the atmosphere, promising to bring the lumbering system of balloons and rockets for studying weather and climate into the new age of robots and computers. Such is the "pipeline" effect in space experiments that my timidly expressed interest in "getting involved" with this project actually materialised in the form of the third Oxford space experiment, another new technique called a Pressure Modulator Radiometer or PMR, which was launched on the sixth satellite of the Nimbus series. The launch took place in 1976, ten years after the idea for the PMR was first mooted and six years after the first prototype staggered into the air on a high altitude balloon one freezing morning on Salisbury Plain. The successful flight had the PMR hanging 40 km above Stonehenge, measuring blessedly sensible data, after two excruciating failures at Cardington in the shadow of the old hangar which used to house the leviathan and equally ill-fated R101 airship. The methodical rise and fall of the pen recorder, as the PMR cycled between measurements of the atmosphere and its warm and cold calibration targets, was more beautiful than the Mona Lisa to the perspiring supplicant for the D.Phil. on the ground beneath. Years later, the first few bits of data on the infrared temperature of Venus would echo that feeling, as the NASA Pioneer spacecraft edged into orbit around the Earth's prodigal twin and expectantly opened its infrared and ultraviolet eyes

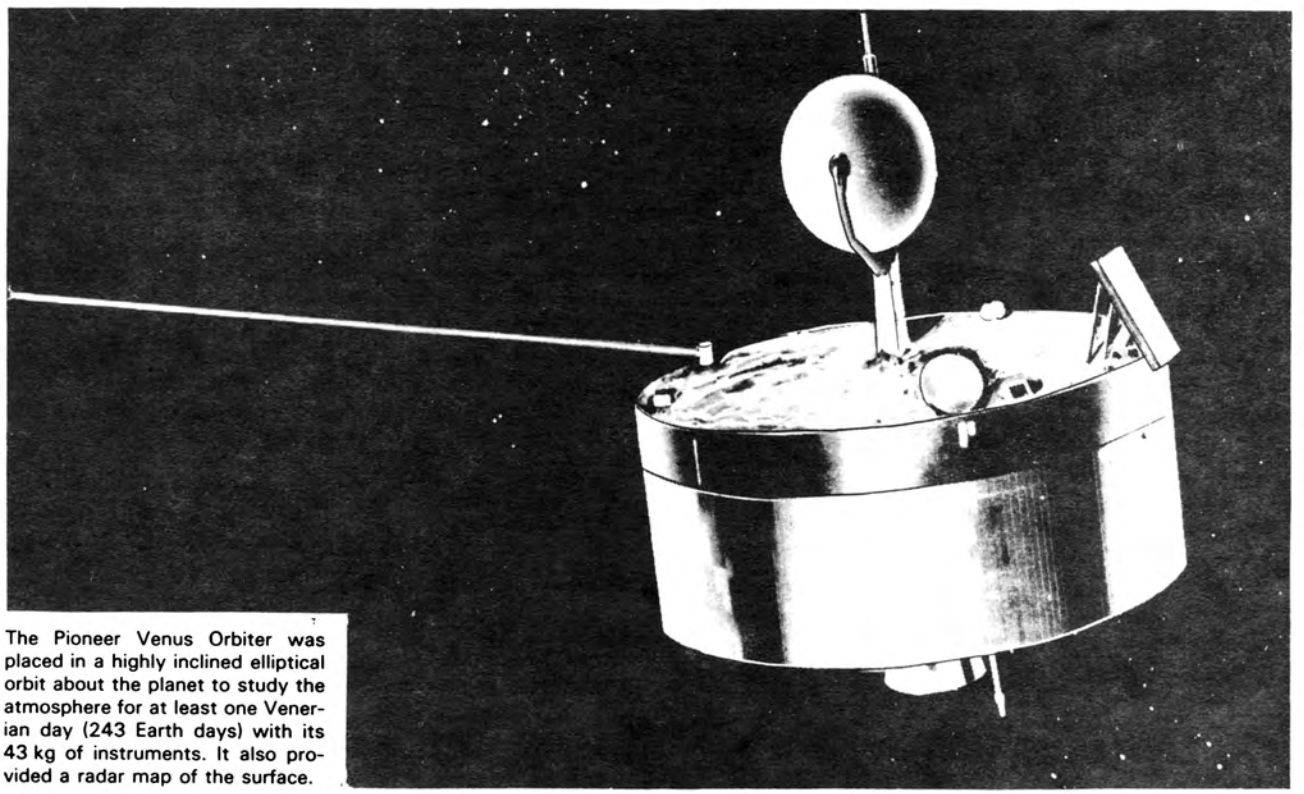
Personal Profile/contd.



Not an abstract painting but a computer enhancement of the first image of Venus' northern hemisphere returned by the Pioneer Venus Orbiter's infrared radiometer in December 1978. The pole is revealed to be −30°C, some 30°C warmer than the surrounding cloud band.

Across the Big Pond

With the D.Phil., and the PMR's place on Nimbus 6 ensured, even before the flimsy prototype trailing sheets of balloon smashed into a Gloucestershire farmer's field merely feet from his prize Jersey, thoughts turned to what to do next. Most students leave Oxford reluctantly; nowhere else looks attractive by comparison. However, in those days before the American space programme lost its innocence, the lure of the other side of the Atlantic was irresistable. At the Jet Propulsion Laboratory in California, plans were forging ahead to launch spacecraft to Mercury and to land robots on Mars. My job was to look into what could be done with infrared measurements of the atmospheres of Jupiter, Saturn, Uranus and Neptune as part of a precursor study for the Outer Planets Grand Tour. This was a project conceived on a sweeping scale, too expensive to survive, whose trimmed-back remnant is still with us as Voyager 2 journeys to Uranus after visiting Saturn. The study showed that temperature profile and composition measurements were possible on Jupiter and Saturn using similar techniques to



The Pioneer Venus Orbiter was placed in a highly inclined elliptical orbit about the planet to study the atmosphere for at least one Venerian day (243 Earth days) with its 43 kg of instruments. It also provided a radar map of the surface.

those we had worked on at Oxford for terrestrial weather satellites. In the atmosphere of white-hot competition which accompanies the selection of experiments to fill the precious space on planetary probes, it happened that our JPL group lost its bid to build an instrument for Voyager to put our study into practice. Instead, the privilege went to a rival group at the Goddard Space Flight Center on the Eastern coast of the USA. In the event, this turned out for the best. The Goddard team did an outstanding job and Galileo – then still to be thought of – was to come, and we turned our attention to Venus:

It is a gross oversimplification to say it, but basically one studies the outer planets in order to learn about the origins of the Solar System, while one studies Mars and Venus to try to understand why planets so similar to the Earth in some ways are so different in others. Venus, in particular, is curious because it retains such a dense, hot atmosphere in defiance of our expectations. The notion of the "runaway greenhouse" attracted a lot of attention in the 1960's in connection with Venus. This theory proposes that very strong positive feedback mechanisms exist in atmospheres containing a lot of water vapour and carbon dioxide, like those of the terrestrial planets.

Negative feedback mechanisms are also present, producing a kind of stability which may be an illusion. The state of Venus, the climate record on the surface of Mars which stares back at us from the Viking pictures, and the history of terrestrial ice ages, all suggest that it is. What sort of balancing act is the atmosphere of the Earth playing with the future of Mankind? Can there be any more fascinating, any more vital question in scientific research today? And part of the answer must lie in the study of the Earth-like planets, because we cannot experiment with changing the conditions on Earth to see what happens. In another curious and rather frightening sense, the adventure of space is relentlessly turning inside out. Far from the confidence of the 1960's and before, when we humans saw ourselves confidently poised to expand outwards in search of new destinies, we suddenly begin to suspect that we must understand the planets, and fast, if we are to keep the old one.

The Pioneer Venus mission was not conceived in this new attitude of fascinated desperation, which even in the 1980's has still to really take hold in the minds of many people whose attitudes will shape our future in space. For me in 1973, as I wrote the proposal to NASA for an Oxford-style radiometer to go on board the Venus orbiter, it was with excitement and curiosity in mind. We were going to take a proper look at another Earth-like atmosphere for the first time. So it proved.

Between the euphoria of being selected to be one of the privileged few to join a new mission, and actually getting there, a great gulf yawns. It is full of tight schedules, cost over-runs, nights without sleep in front of control panels, endless, interminable meetings, travel to contractors in grotty suburbs of faceless cities to try to squeeze your precious detectors, or circuits, or whatever, out of them before they squeeze the last drop of blood out of you. It is Salisbury Plain at six in the morning, Cardington after your balloon has burst early; all of this magnified a thousand times. No-one should go to that palace of high technology, on the hillside overlooking the sprawling Southern California metropolis and the distant Pacific, with their eyes closed. Sometimes, you step out of your air-conditioned office into the dry heat just as the Sun is setting and see a pencil of flame shedding multi-coloured smoke far to the north. It is a rocket leaving Vandenberg Air Force Base for space, with somebody else's instruments on board. That keeps you going. At last, your turn comes. Cape Canaveral, Cocoa Beach, Daytona; a perfect launch. Disney World to unwind. A six month cruise to Venus, no way to test the instrument. Encounter at last, just before Christmas; bug-eyed from watching the screen, up all night. Pioneer docks safely. The cover comes off, data floods back. Just zeroes at first, then the numbers that spell out the temperature of the equatorial cloud tops: −35°C, that's right. It works. Wait, something's wrong. The North pole is too hot. The damn thing's going off scale. Switch to low gain, wait for the next orbit. It's still there; hot beams of infrared are coming up from the pole, two of them, surrounded by a band of intense cold. No-one has ever seen this before; Venus is stranger than we thought. After three months, it all goes dead as the power supplies in the instrument fail, leaving us with a mass of fascinating data it will take five years to analyse. Time to go home.

After an absence of nearly ten years, Oxford has hardly changed. But then, it hardly ever does. What has changed is the European space scene, more organised and awaking to its own role in Earth orbit and beyond. A probe to intercept Halley's comet is being built. A Mars orbiter is in the design stage in the aerospace industry, a new mission to Venus, even one to Titan is being talked about. Nimbus is gone, but we collaborate now with the Americans on Earth satellites of incredible sophistication, each one the size of a lorry. The Oxford instruments one used to be able to hold in one hand are now the size of tea-chests and need a small crane to lift them. They measure temperature, pressure, winds, tiny amounts of pollutant gases that react with the ozone layer and threaten to change the climate. In the midst of recession, people realise that we need to understand these things: the future looks bright. Grandfather would have approved.

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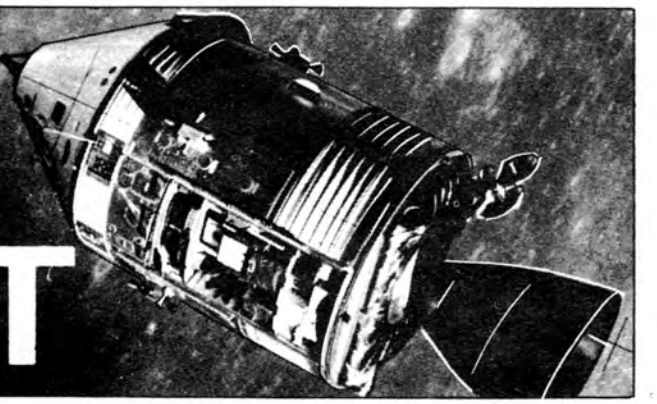
SPACE REPORT



THE END OF DELTA?

NASA has notified McDonnell Douglas that production of Delta launch vehicles should end with no. 178, although components for three others will be produced. By February of this year 13 were scheduled to fly: eight more this year, two in 1984, one in 1985 and two in 1986. With the problems of Shuttle Orbiter *Challenger* before its first flight on STS-6 there were proposals for removing some of the smaller satellites from STS-7 and -8 to Delta, although they eventually stayed with the reusable craft.

NASA was originally using Delta as a backup to Shuttle but has now decided that the Shuttle, despite its problems, can meet its commitments. There is a possibility that Delta could be marketed on a commercial basis although the right to use NASA and USAF facilities at the Cape and in California would have to be negotiated.

. . . BUT NOT YET

The European Space Agency switched the launch of Exosat (European X-ray Observatory Satellite) from Ariane to a US Delta rocket in late February. Delays with Ariane forced the change for Exosat, which had been scheduled to go into a Sun-synchronous orbit in November last year. Liftoff *via* Delta now is planned from NASA's Western Missile and Test Range at Vandenberg Air Force Base in California at the end of May.

The launcher is a three-stage Delta 3914, which will take the 1125 lb (510 kg) payload into a highly eccentric polar orbit. The satellite will take four days to complete a single orbit, coming as close as 217 mi (350 km) to Earth, then swinging out to some 124,400 mi (200,000 km) over the North Pole.

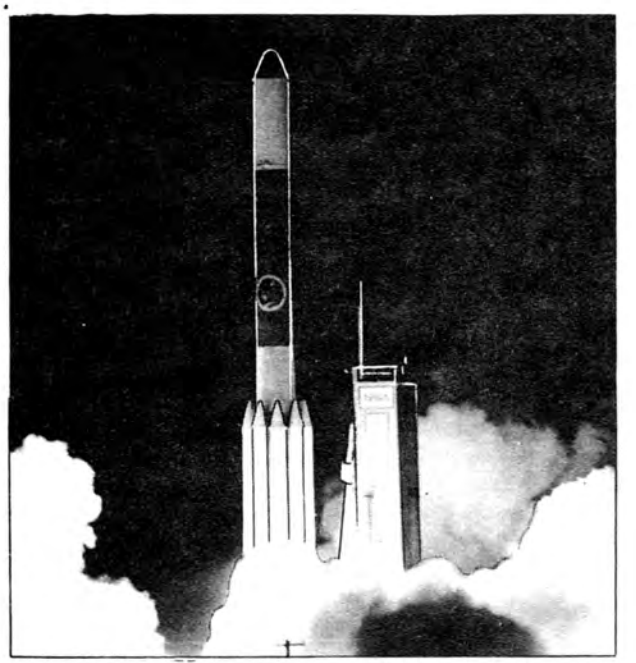
Current plans call for two years of operations, providing astronomers with detailed new information regarding X-ray emissions from individual sources, both within the Galaxy and beyond.

The launch is the fourth out of nine Deltas scheduled for 1983 and the second from Vandenberg. Since it began missions for NASA in 1960, Delta has launched 155 scientific and communications satellites. Dubbed the "Workhorse of Space" because of its reliability, Delta has recorded a 97 per cent success rate during the past five years. In August 1982, it reached a milestone for large multistage expendable vehicles with its 30th consecutive success. That record was increased to 32 in January.

MORE IUS ORDERED

The US Air Force has asked Boeing Aerospace Co. to supply six more Inertial Upper Stages now that the first two have completed their space missions. The more recent one took the large NASA data relay satellite from *Challenger's* cargo bay during the STS-6 Shuttle mission.

The contract calls for the delivery of the six, plus backup parts and six refurbishment kits for the "airborne support equipment" already provided by Boeing and used by the Space Shuttle to carry and launch the IUS and its payloads. The newly ordered IUS vehicles will be delivered between this November and April 1985; cost for each is about $42 million.



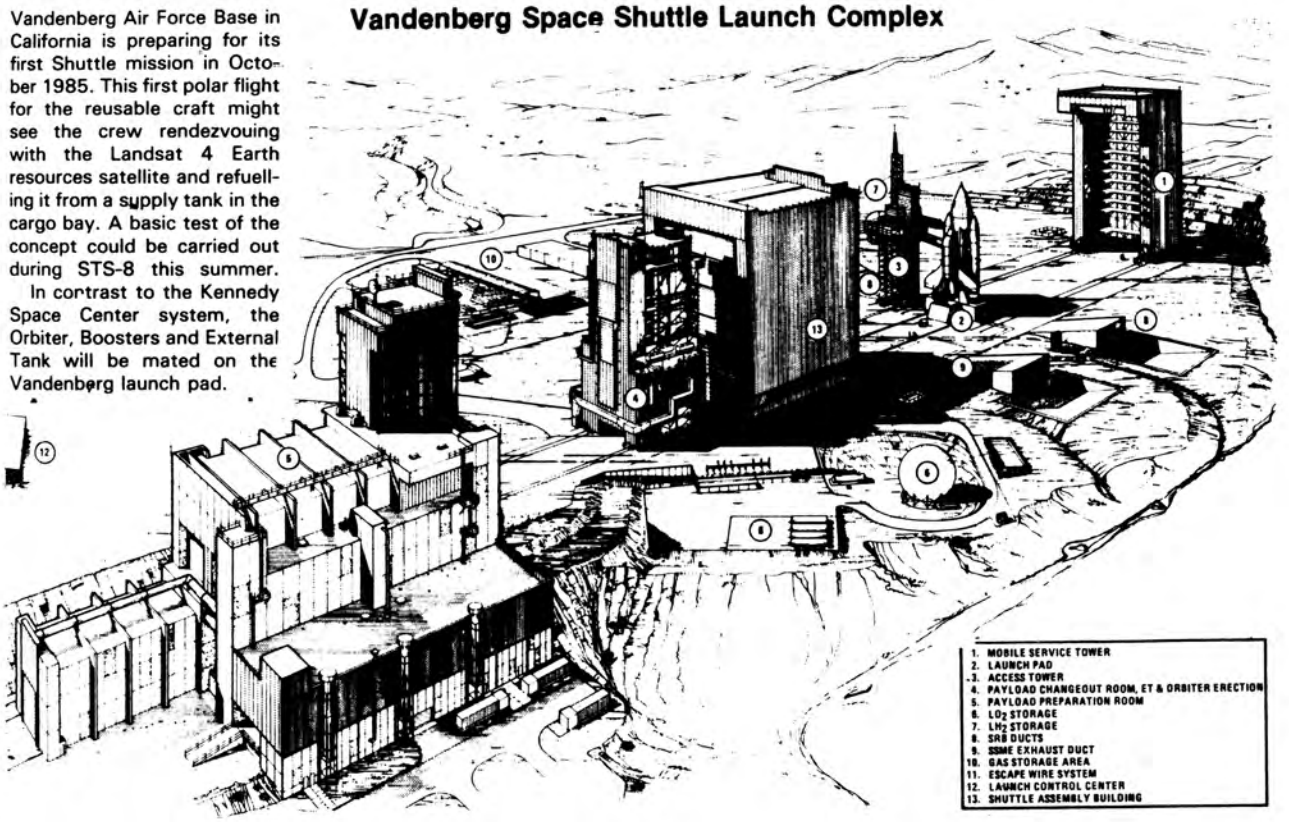
Launch of the Infrared Astronomical Satellite in January by another successful Delta rocket.

NASA

Vandenberg Space Shuttle Launch Complex

Vandenberg Air Force Base in California is preparing for its first Shuttle mission in October 1985. This first polar flight for the reusable craft might see the crew rendezvouing with the Landsat 4 Earth resources satellite and refuelling it from a supply tank in the cargo bay. A basic test of the concept could be carried out during STS-8 this summer.

In contrast to the Kennedy Space Center system, the Orbiter, Boosters and External Tank will be mated on the Vandenberg launch pad.



The two-stage IUS is a solid propellant upper stage for both the Shuttle and the US Air Force's Titan-34D rocket. The first was launched atop a Titan on 30 October last year, successfully carrying two Defense Satellite Communications Systems satellites to their precise deployment points in geosynchronous orbit some 22,300 miles above Earth. The stage is 5.2 m long, 2.9 m in diameter and weighs 14,700 kg; the first stage can generate up to 20,700 kg of thrust, the second up to 8,400 kg. By combining extremely high reliability parts, stringent testing and extensive backup systems, the IUS has a predicted reliability of better than 98 per cent, a figure never before reached by similar unmanned stages. Until the modified Centaur comes into service later this decade it will be the largest stage used by the Shuttle.

TIROS CUTS

The US National Oceanic and Atmospheric Administration (NOAA) is proposing to cut its Tiros polar weather satellites from two to one, with an estimated saving over ten years of $375 million. Tiros-E (NOAA 8 in orbit) was scheduled for launch in March and after its expected lifetime of 20 months it will not be replaced. By then, only the planned Tiros-F (NOAA 9) will be operating, leading to a saving in data analysis costs.

The Tiros H-J satellites (described on p.357 of the Sept/Oct 1982 issue) will now be postponed.

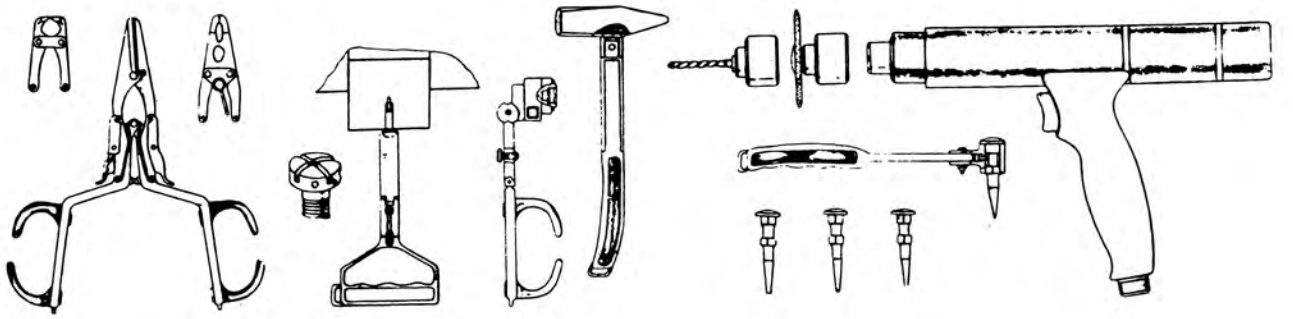
COSMIC·TOOL KIT

Soviet cosmonauts Anatoli Berezovoi and Valentin Lebedev, during their 211-day space flight in 1982, carried some 17 kg of tools for repair jobs on the Salyut 7 space station, writes Neville Kidger. This was revealed by Mikhail Gelfand of the "Moscow Research and Development Association for Building Power Tools and Finishing Machines" – where the tools are designed and built – in an interview for the *Soviet Union* magazine.

The tools included screwdrivers, saws, drills, hammers and special equipment for conditioning metal before welding. During their 153 minute space walk on 30 July 1982 Berezovoi and Lebedev unscrewed a set of externally-mounted bolts and nuts with a special tool.

Tools taken into space have to be specially designed for the unique weightless conditions. The Soviets have designed hammers with hollow heads filled with metal shot (to prevent recoil) and a drill with an electric drive to neutralise reaction torques which would normally make the cosmonaut spin in the opposite direction. Other tools included nippers with rubber loops to secure them to the gloves of the cosmonaut's space suit and a 27V soldering iron resembling a ball-point pen.

According to Gelfand, the first to take a tool kit into space was the Soyuz 9 crew of Nikolayev and Sevastyanov. That kit weighed only 740 g and consisted of ordinary commercial tools, a screwdriver, knife, pliers and scissors. They were carried only in case of an emergency.



With the launch of Salyut 6 it became necessary for cosmonauts to be able to repair on-board equipment, so more sophisticated tools had to be developed. The Soyuz T-3 crew used a special kit to replace a sealed temperature control system pump which had not been designed for replacement. Because of the amount of repair work done by this crew and their predecessors on the 175-day flight in 1979, they adopted an unofficial mission emblem showing two crossed wrenches!

NEW SHUTTLE PARACHUTES

The first of three "drop tests" to check out improvements of the Space Shuttle booster's parachute system was made in late February at the US National Parachute Range at China Lake in California. The present system consists of a small pilot 'chute, a drogue 'chute and three main 'chutes 115 ft (35 m) in diameter; the new main 'chutes will be 136 ft (41.4 m) in diameter.

By using the larger main parachutes the boosters will hit the water at a slower speed (82 kph instead of 98 kph) than before. This will reduce the amount of damage that will have to be repaired before the boosters can be used again.

The drop tests are using a test article which is one third the size of a proper booster, together with one full scale parachute. The article is attached to a modified B-52 aircraft and dropped from 6,000 m. After the tests are completed this year the large parachutes should enter service by mid-1984.

SPACE COMMERCIALISATION

At a recent meeting of the US House of Representatives' subcommittee on space science and applications, John Yardley, President of McDonnell Douglas Astronautics Company and James Rose, Manager of the company's Electrophoresis Operations in Space project (EOS), said that policies favourable to business would encourage the industrialisation of space and the development of new technologies.

McDonnell Douglas, in collaboration with the Ortho Pharmaceutical Corporation, provided the EOS unit taken on the fourth and sixth Space Shuttle flights, writes Neville Kidger. The unit, using a process called Continuous Flow Electrophoresis, separates materials in solution by using an electrical field. The process can produce pure biological substances, useful in combatting diseases, in quantity and with a high degree of purity. For example, during the STS-4 tests, the device separated mixtures of egg albumen and rat albumen as well as a cell culture containing many types of proteins in quantities some 500 times greater than those possible in similar Earth-based units. The results of the STS-4 tests alone, according to McDonnell Douglas, show that the system has the potential for becoming a commercially viable method of producing drugs in space.

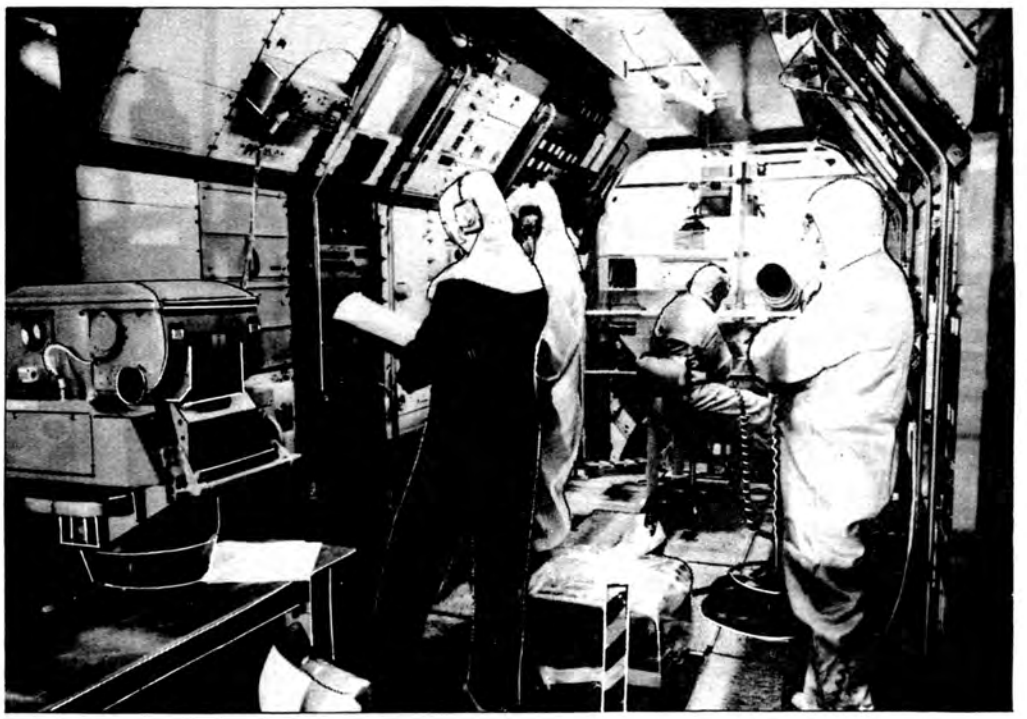
Tests will continue aboard the Shuttle and a production prototype unit is scheduled for two development flights on Shuttle starting in mid-1985. If the flight tests are successful, the companies hope to have a production unit in orbit by 1987.

The project is part of NASA's "Joint Endeavor" policy, under which the space agency provides flight support to McDonnell Douglas for precommercial development of the process. The high risk of space processing could be discouraging to some industries, Yardly believes, since a space-based system is solely dependent upon the Government for access to space. A stable policy guaranteeing commercial users access to space is needed. Other improvements would include a stable pricing structure for the Shuttle and a commitment to the development of a space station or a free-flying space structure which would be made available to industry.

"Since the Space Shuttle is a national system which the Government plans to sustain for 20 years or more, the development of a commercial market could actually reduce the Government's funding for its operation. Each Shuttle flight made for commercial purposes would reduce the necessary Government funding to about $50 million. Thus it is of real direct benefit to the Government to develop commercial users. Other economic and social benefits will accrue from the development of new technology and products for domestic and worldwide sales," Yardley concluded.

NEW ARIANE SCHEDULE

At its meeting on 23/24 February, ESA's Council established a new launch schedule because of the delays forced by the L5 failure last September. Ariane L6 is now scheduled for 3 June and the L7, L8 and L9



Technicians run through a flight test sequence inside the Spacelab pressurized module to check that the experiments are properly installed. Spacelab should be inserted in the Shuttle Orbiter *Columbia* this summer; next month we hope to carry a report on the modifications on the Shuttle craft in preparation for this autumn's mission.

NASA

launches for 26 August, 4 November and January 1984, respectively. L6 will carry the ECS-1 communications satellite and the Amsat radio payload; the others will all orbit Intelsat 5 communications satellite.

The first of the Ariane 3s, L10, is currently scheduled for March 1984. Ariane 3 is a more powerful model, capable of injecting two spacecraft, each of up to 1,195 kg, into geostationary transfer orbits. The Agency's ECS-2 and Marecs-B2 satellites, the French Telecom-1A and B, the Arab League satellite, Arabsat-1, as well as the US Western Union's Westar-6, Southern Pacific's Spacenet-1 and 2 and GTE's G-Star 1 and 2 will be launched by Ariane 3.

The Ariane 1 freed by the transferral of Europe's Exosat astronomical satellite to a US Delta vehicle will now be used for the Giotto Halley's comet probe in July 1985.

ASTRONOMICAL EXPERIMENTS

A new space experiment carrier called Spartan (Shuttle Pointed Autonomous Research Tool for Astronomy) has been developed at NASA's Goddard Space Center, writes Joel Powell. The free-flying payload, which occupies less than 5 cubic ft (0.14 m^3) and weighs less than 2,000 lb (900 kg), will be deployed by the Shuttle manipulator arm. Spartan 1, with a set of Naval Research Laboratory X-ray detectors, is scheduled for STS-17 in Spring 1984. Spartan 2, carrying two solar coronographs (UV and visible light) is ticketed for a late 1985 launch. Although not yet funded, Spartan 3 should follow with an ultraviolet payload.

Two ultraviolet astronomy experiments are destined for a new Naval Research Laboratory package named SURE (Space Ultraviolet Radiation Environment). Riding in the Shuttle cargo bay, an extreme ultraviolet spectrometer and a far ultraviolet imaging photometer will examine targets ranging from the terrestrial upper atmosphere to galactic sources during the mid-1980's.

AURORA EXPERIMENT SUCCESSFUL

After failing a year ago to disturb auroral formation with water (*Spaceflight*, Sep/Oct 1982, p.348), 50 Canadian and American scientists succeeded late on 6 February when the "Waterhole 3" experiment was launched from Churchill in Canada on a Black Brant IX rocket. The 180 kg "waterbomb" did not dim the aurora on this occasion, but a sharp reduction in the flow of particles from deep in the magnetosphere was recorded, providing valuable clues to the complex auroral process.

CHEAP EXPERIMENTS

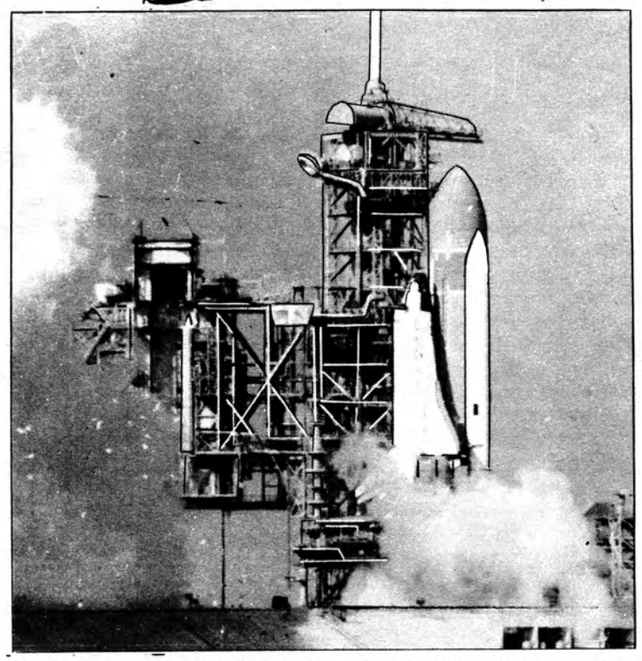
Several new cheap and flexible Space Shuttle payloads based upon sounding rocket technology are to be built, writes Joel Powell. A payload class known as "hitchhiker" is near to approval with an initial flight expected on STS-14 in Spring 1984. A "bridge" in the cargo bay will carry engineering, scientific and military payloads with a lead time as little as six months (with minimum paperwork) from proposal to flight. Involving EVA work by the crew, the first experiment candidate is a Massachusetts Institute of Technology student beam construction demonstration.

CHALLENGER MEETS THE CHALLENGE

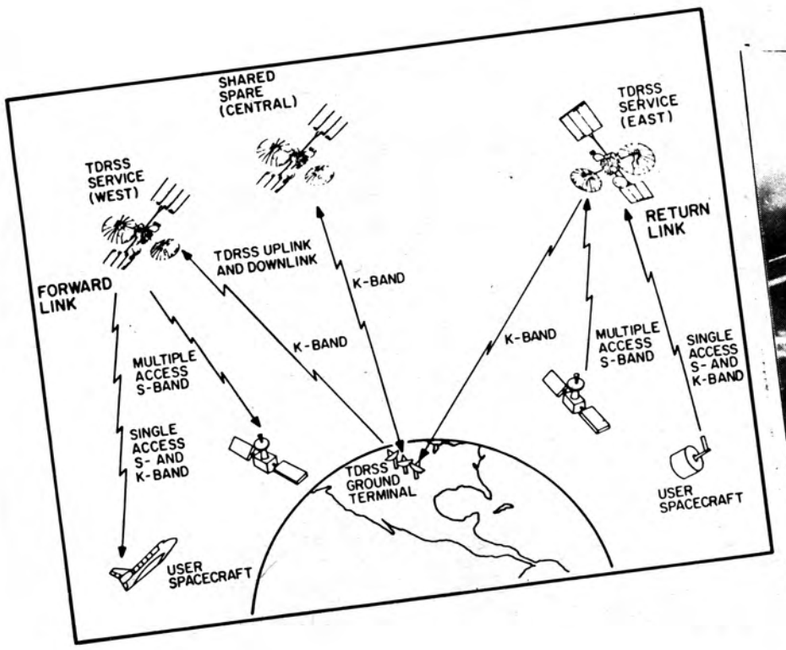
As followers of the "Milestones" section will know, the sixth Space Shuttle had its share of ups and downs. When the highly successful fifth flight finished last November, STS-6 was expected to take to the skies in late January 1983. But it was not to be. *Challenger* was brought to the pad on 30 November and a short firing of its three new engines on 18 December appeared to go well. But then engineers discovered there was a hydrogen leak somewhere around the rear and another firing on 25 January led them four days later to a 2 cm crack in a fuel line in the No. 1 (2011) engine. Two replacements were brought in – one also turning out to leak – and then engines 2 and 3 were found to be leaking. Result: *Challenger* on the pad with no main engines and consternation among those shuffling this year's launch schedule around.

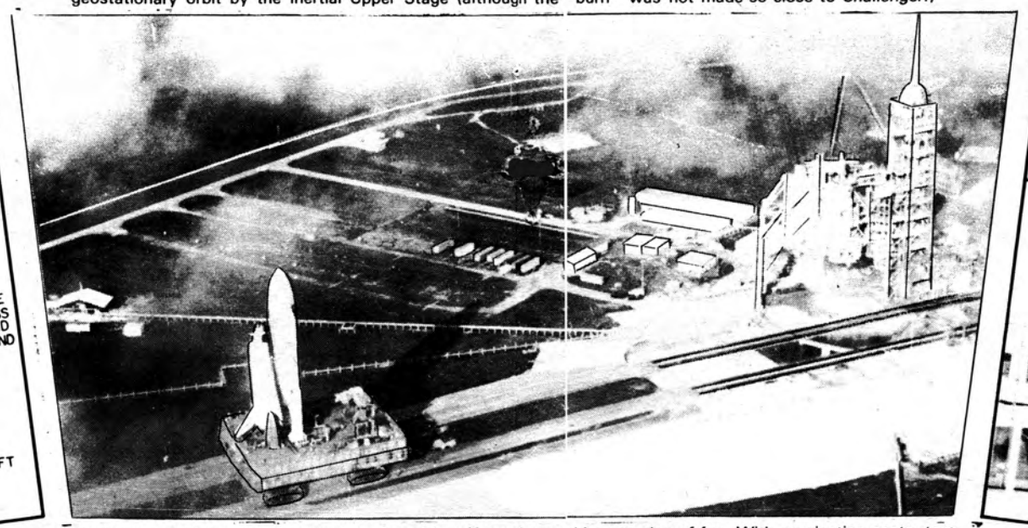
Challenger's main task was to launch the first of the TDRSS (Tracking & Data Relay Satellite System) craft, weighing 2,250 kg. A second launch by STS-8 (plus a spare next year) will bring the system up to capacity, allowing ground stations to remain in contact with manned spacecraft for much longer (the TDRSS will be in geostationary orbit and in view of a low orbiting Shuttle for long periods). A problem with the delays is that the second TDRSS might not be in service when Spacelab flies this October and a great deal of the scientific data from the experiments could be lost (there will be too much to store on on-board tape recorders).

The STS-6 crew. Left to right: Don Peterson, Paul Weitz, Story Musgrave and Karel Bobko. Only Weitz, the commander, has flown before (Skylab, 1973); the others have all had to wait since the 1960's for their first trip into space. Behind is the mission badge, showing the TDRS satellite being boosted towards its geostationary orbit by the Inertial Upper Stage (although the "burn" was not made so close to *Challenger*!)



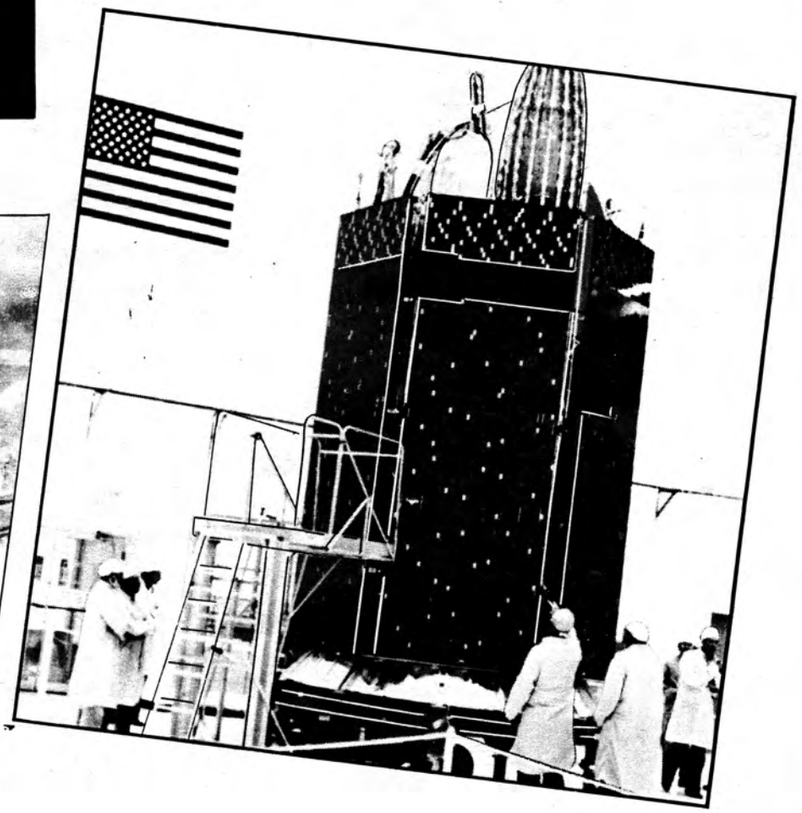
Above: Challenger's main engines thunder out their power during a 20-second test on 18 December at a time when the flight was expected in late January. *Below:* the waiting TDRS was eventually installed in the Orbiter's cargo bay in February.





Challenger was transported to the launch pad last November amid a covering of fog. With no ejection seats, test instrumentation and with experience gained with earlier Orbiters, *Challenger* weighs 5,400 kg less than *Columbia*.

All photographs courtesy of NASA.



T 26

NEWS FROM THE CAPE

By Gordon L. Harris

EFFECTS OF STS-6

Embarrassed by the engine failures that caused several months' delay in *Challenger's* first launch, NASA has given up hopes of achieving the widely advertised payload capability (65,000 lb, or 29,500 kg, when fired due East, half that amount into polar orbit from California) until 1985 at the earliest.

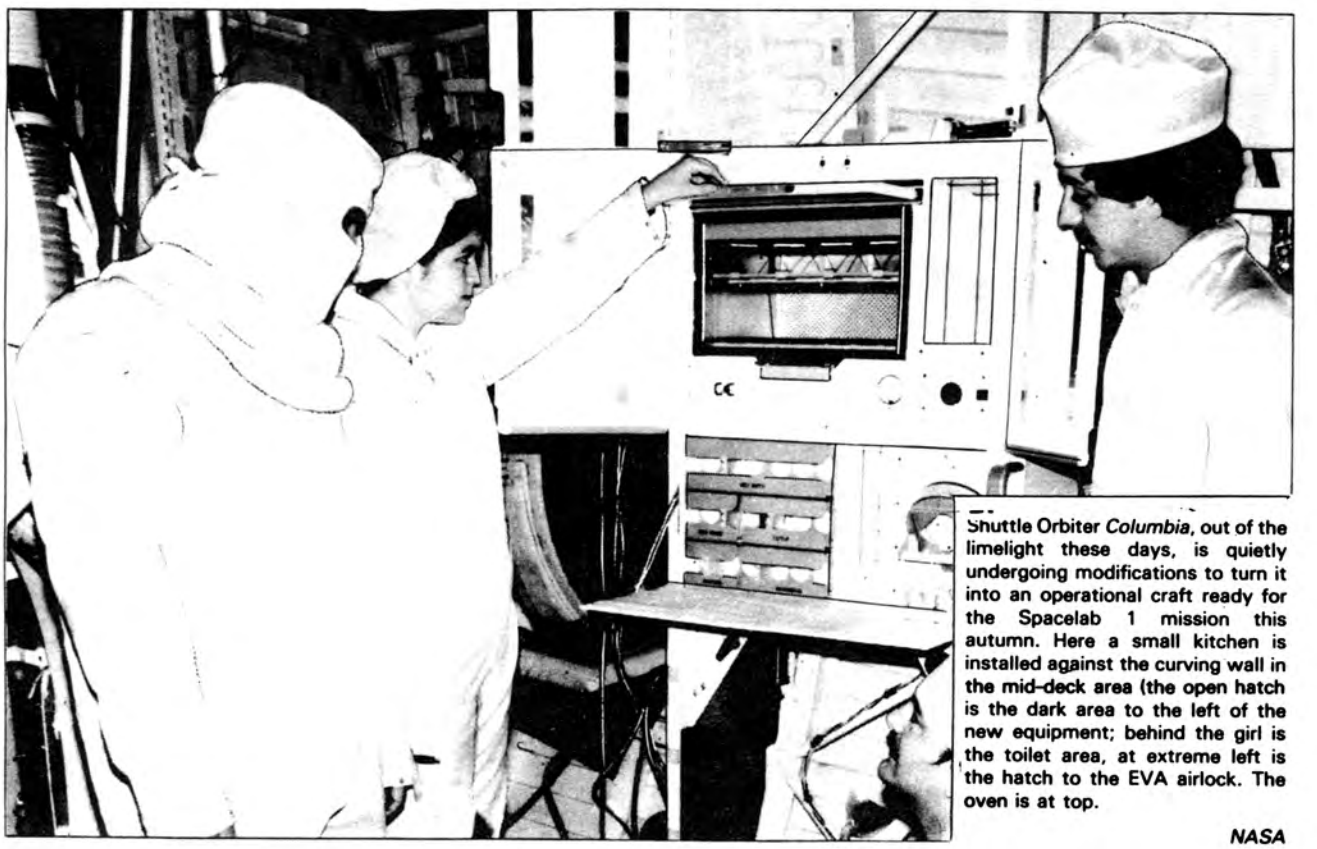
Lt.-Gen. James Abrahamson, US Air Force, on assignment to the agency as associate administrator, admitted the major change during a press briefing. Not until a Shuttle carries a secret Defense spacecraft at Vandenberg Air Force Base will it now be necessary to achieve maximum capability. Meanwhile, weight reduction efforts and higher performance solid boosters are counted upon to increase cargo potential.

Because of the unexpected slip from late January until April, Abrahamson said the remaining 1983 launches would also slip. An optimistic revised schedule in February called for STS-7 in May, STS-8 in July, and Spacelab 2 (aboard *Columbia*) in September. If, and Abrahamson implied that it was a big "if", NASA achieves that timetable "we will have fully recovered" from the engine failures.

A flight readiness firing on the pad in January confirmed there was a hydrogen leak but a second test was needed to pinpoint the trouble spot: a split in an engine manifold. That engine was removed and another brought in from the Mississippi test site. Then technicians discovered that its liquid oxygen heat exchanger was also leaking. That, Abrahamson, told newsmen, presented a critical problem. So it was decided to remove an engine from *Columbia* (all three of its engines were in California for refurbishment) while completing the testing of another new engine in Mississippi. The latter is designed to operate at 104 per cent of design thrust as are the two engines in *Challenger*. *Columbia's* engine, on the other hand, could not be fired at that rate. If used, it would have required a revision of the flight profile to balance its lower output against the higher thrust of the others. Uprating hydrogen-oxygen main engines is part of NASA's plan to reach the payload maximum claimed for the system since its beginning in 1972.

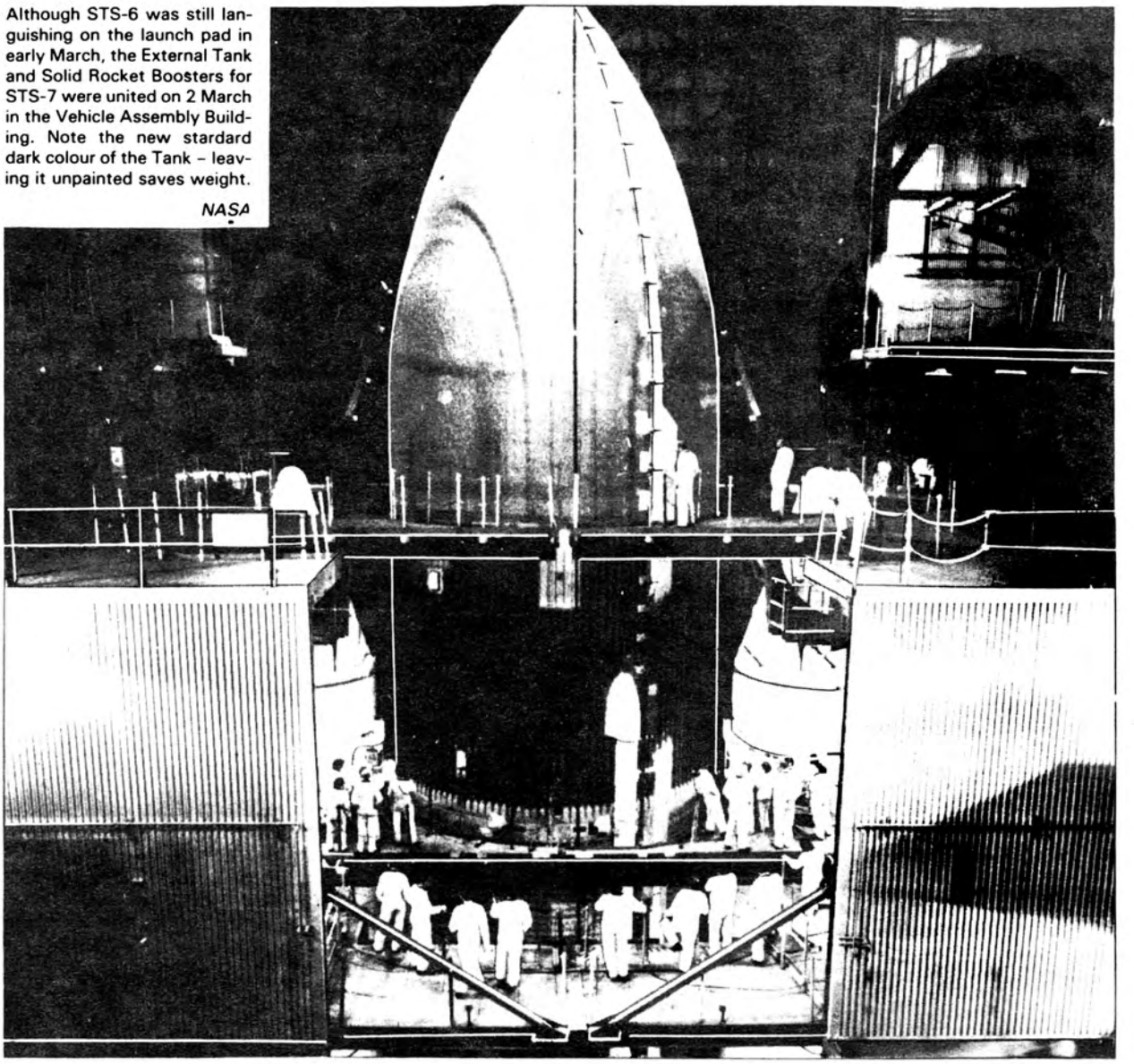
Meanwhile, the Kennedy Space Center has changed work schedules to provide full manning 24 hours a day, seven days a week. The agency did not supply any figures on the cost of the slippage or the recovery effort. Nor did Abrahamson explain why he talked of more intensive quality control, inspection and testing, having recently declared that pre-launch tests must be reduced to save time and cost.

He said the European Space Agency would approve a 30 September liftoff for Spacelab 1 if NASA fails to put the second tracking and data relay satellite in orbit in July with STS-8. The first was in *Challenger* for the STS-6 April launch.



Shuttle Orbiter *Columbia*, out of the limelight these days, is quietly undergoing modifications to turn it into an operational craft ready for the Spacelab 1 mission this autumn. Here a small kitchen is installed against the curving wall in the mid-deck area (the open hatch is the dark area to the left of the new equipment; behind the girl is the toilet area, at extreme left is the hatch to the EVA airlock. The oven is at top.

NASA



Although STS-6 was still languishing on the launch pad in early March, the External Tank and Solid Rocket Boosters for STS-7 were united on 2 March in the Vehicle Assembly Building. Note the new stardard dark colour of the Tank – leaving it unpainted saves weight.

NASA

EXPLORER REMEMBERED

The 25th anniversary of Explorer I, the first US satellite, passed rather quietly on 31 January. Three events commemorated the occasion: Dr. William Pickering, then director of the Jet Propulsion Laboratory, delivered the von Braun lecture in Washington on 23 January; 67 of the Army missile team in Huntsville attended a reunion at Alabama's Space and Rocket Center on 31 January; and 70 more attended an informal reception arranged by Kennedy Space Center director Richard Smith at the launch site.

There Major General, now the Very Reverend, J. Bruce Medaris told his former associates that "fame is indeed fleeting". In 1958, he added, "every bartender in Cocoa Beach recognised me at a glance and my favourite drink would be placed before me as I sat down." He smiled as he concluded: "Today I had to spell my name to get through KSC guards." Before he left the launch base he proudly displayed a photo badge arranged by Director Smith. Never again would he have to spell out his name at a KSC gate.

His comment was timely. Major TV networks, despite written reminders of the date, ignored the anniversary. Not so Orlando's (in central Florida) stations, each of which mentioned the event on their nightly newscasts. So did local newspapers, while the Associated Press carried an anniversary story, illustrated with time-worn photos of General Medaris, Dr. Kurt H. Debus, then director of the Missile Firing Laboratory of the Army Ballistic Missile Agency, and Robert Moser who conducted the launch countdown.

Could the US have launched a satellite before the USSR if the Army had been permitted? Twenty five years later Debus replied with an emphatic "Yes!" His former military commander entered the priesthood in 1970, believing that his recovery from osteosarcoma was made possible by Divine intervention.

T 28

SPACE AT JPL

The latest news from Dr. William McLaughlin at the Jet Propulsion Laboratory in California

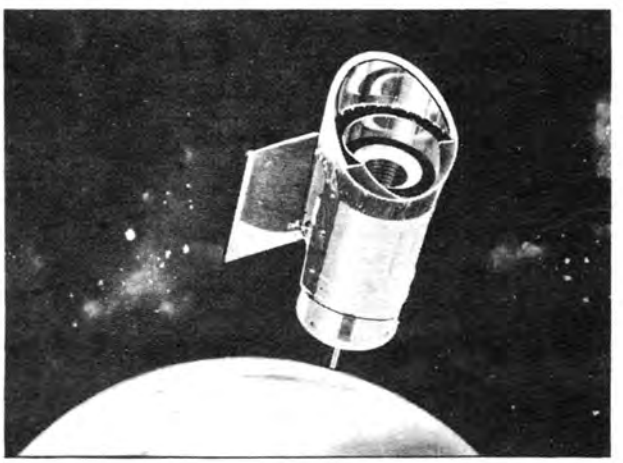
IRAS IN ORBIT

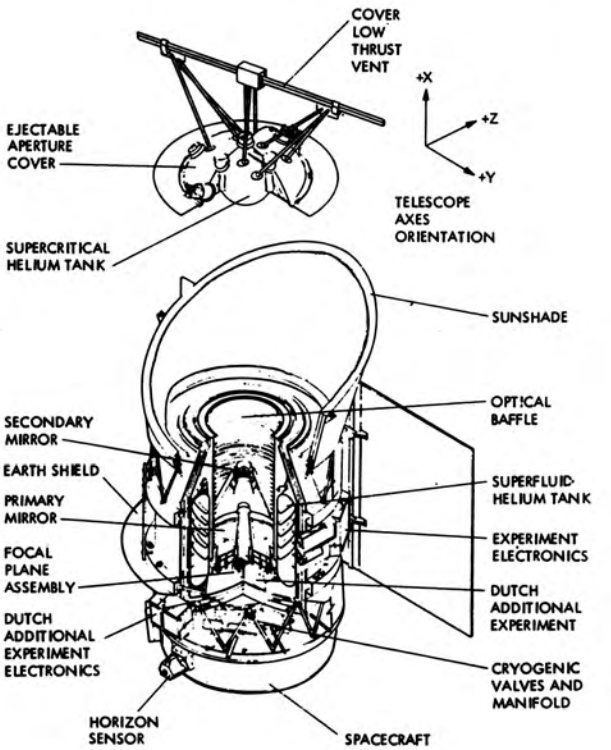
The Infrared Astronomical Satellite (IRAS) was placed accurately into its 900 km orbit by a Delta 3910 from the Vandenberg Air Force Base in California on 26 January. Although the launch went without incident, it was in doubt until the last hour or so due to very strong winds at 12,000 m. It was not until the final meteorological report was received that all was "go" for launch.

I had driven the 240 km north from JPL to Vandenberg to see the launch and looked with more than casual interest as the rocket slowly lifted from the pad in a glare of electric-white light; almost seven years of work on the IRAS project meant there was a large personal investment for me atop that Delta.

The glare clearly lit up the underside of the cloud deck as the rocket rose skywards. The launch was quite visible from JPL according to observers who also saw the second stage ignite, an event denied to those of us on site because of the local clouds (see the eye-witness account on p.184 of the May issue – Ed.).

IRAS is a joint project between the US, The Netherlands, and the UK. It consists of a 57 cm infrared telescope, sensitive in the 8 to 120 micron range of the infrared, plus a low-resolution spectrometer and two auxilliary instruments. The main purpose is to survey the entire sky and, secondarily, to study selected objects. Due to absorption of the longer infrared wavelengths by the atmosphere, this region of the spectrum is one of the least explored by astronomers. (For more details on IRAS see the January special *JBIS* issue.)

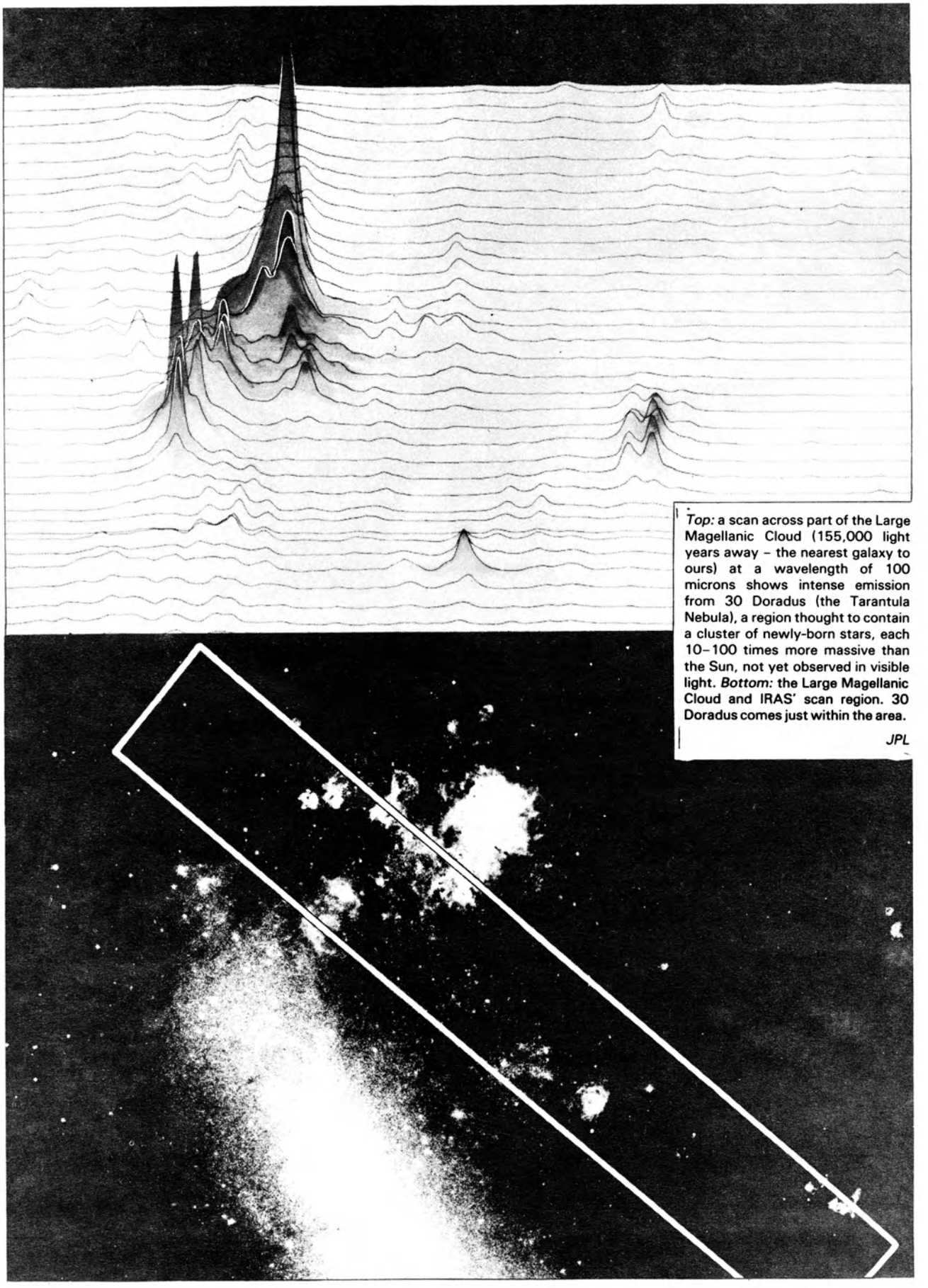




Next day I boarded a 'plane for England to take part in the critical first month of satellite operations. The control centre is at the Rutherford and Appleton Laboratory near Chilton, about 30 km south of Oxford. Also there is the 12 m antenna used to track the satellite and receive "data dumps" from it twice daily.

The first two weeks were largely occupied with checking out, calibrating and tuning up the complex piece of cryogenic equipment circling the Earth in a near-polar orbit 14 times a day.

For the first five days of the checkout the telescope was operated with a protective cover. On the evening that the cover was blown off, 31 January, most of us gathered in a room at Rutherford/Appleton to watch this critical event; a cheer went up as the TV monitor indicated that the operation had been performed successfully. Now IRAS could see the stars.



Top: a scan across part of the Large Magellanic Cloud (155,000 light years away – the nearest galaxy to ours) at a wavelength of 100 microns shows intense emission from 30 Doradus (the Tarantula Nebula), a region thought to contain a cluster of newly-born stars, each 10–100 times more massive than the Sun, not yet observed in visible light. *Bottom:* the Large Magellanic Cloud and IRAS' scan region. 30 Doradus comes just within the area.

JPL

In his science fiction story "Nightfall" Isaac Asimov tells of the inhabitants of a planet in a multiple stellar system who experience darkness only once every two thousand years, and hence see the stars only at these infrequent periods: ". . . the awful splendor of the indifferent Stars leaped nearer." I felt the same as the flood of new data came washing in from IRAS: infrared galaxies, stars, nebulae and other objects that had not been seen before by man in this way. A scan of the telescope across the Milky Way produced particularly interesting results.

We had to wait a while before devoting the telescope full time to scientific observations, since the in-orbit checkout was still underway.

As with any new operating system, unexpected events appeared. A few hours before we were due to radio the observing program up to the satellite, a last-minute check with the computer showed that two of the planned telescope scans would not work under current conditions! Not wanting to get off to such an inauspicious start, we quickly set to work to solve the problem. A member from each of the three IRAS international partners provided the solution: Sylvia Lundy devised a method to replace the defective scans and constructed specifications for the two replacement scans; Engbert Oord performed the "scan transplant"; and Peter Clegg ensured that the action did not conflict with other satellite requirements.

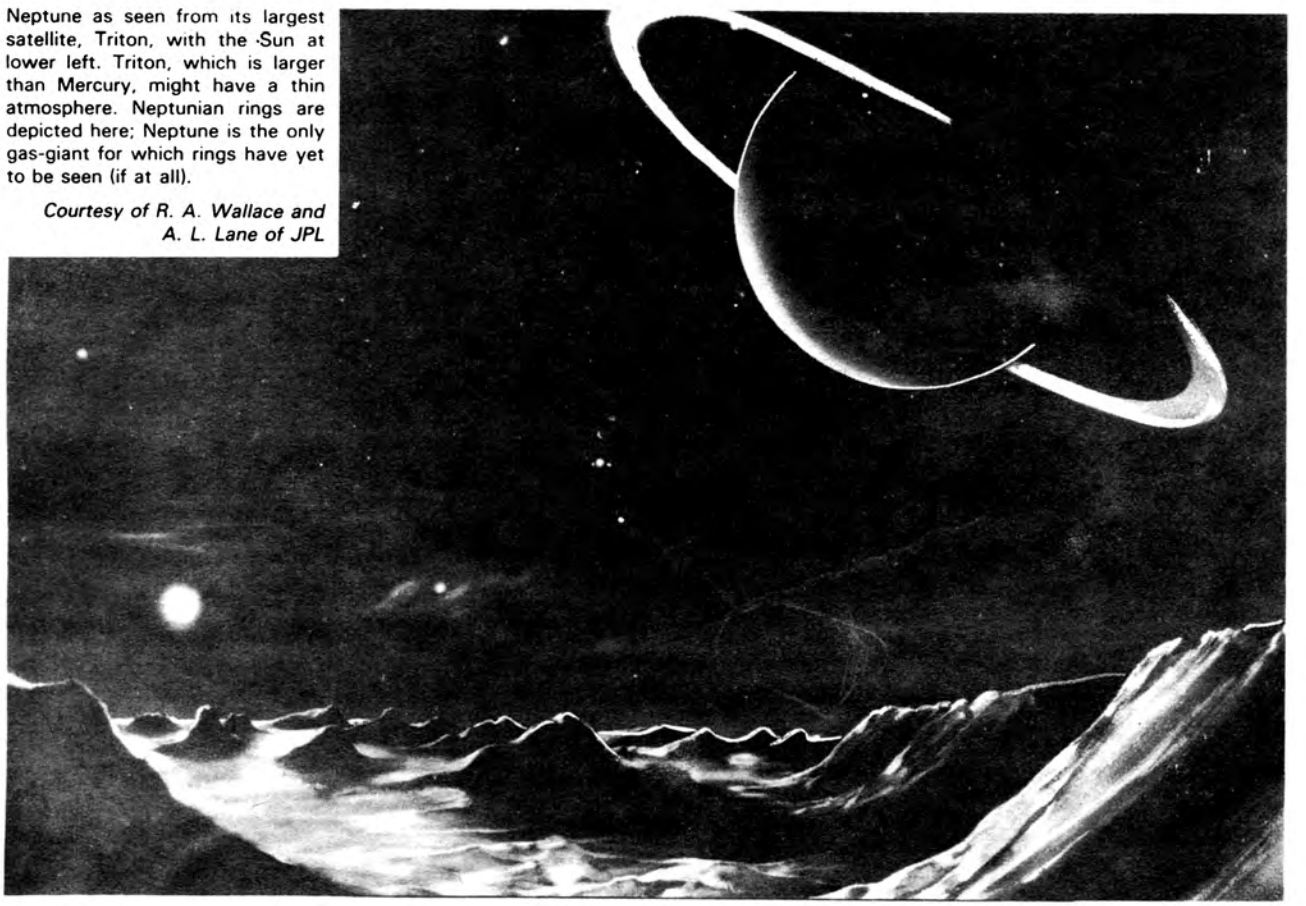
All in all, the IRAS mission has begun very successfully and expectations are high.

GETTING TO NEPTUNE

One of the major obstacles to the exploration of the outer planets is the long flight times that are required before the targets are reached. Voyager 2 was launched from Cape Canaveral by a Titan/Centaur in August 1977. It reached Jupiter in July 1979 and was accelerated by the gravity field towards Saturn for an August 1981 arrival. Receiving a second gravity assist at Saturn, the spacecraft is on course for Uranus in January 1986 and Neptune in August 1989 after a total flight time of 12 years. It should be borne in mind that Voyager was designed to take advantage of the fortuitous alignment of the outer planets during this period; this is an exceptionally target-rich and compact timetable of exploration.

Long flight times increase both the cost of mission operations and the risk of failure due to mechanical or electrical breakdowns. Also, it is probable that very long flight times present a psychological barrier to mission design and approval; it might be difficult to sell a 20-year flight to the outer planets to a society that is accustomed to shorter-term results. Thus, there is considerable incentive to find technological solutions to the flight-time problem.

The description of a series of advanced-concept studies began in the April edition of "Space at JPL" with the Saturn Ring Rendezvous mission. In that study the spacecraft used a nuclear-electric engine to spiral out to Saturn and then hover just above the Saturnian



Neptune as seen from its largest satellite, Triton, with the Sun at lower left. Triton, which is larger than Mercury, might have a thin atmosphere. Neptunian rings are depicted here; Neptune is the only gas-giant for which rings have yet to be seen (if at all).

Courtesy of R. A. Wallace and A. L. Lane of JPL

rings as it crossed their entire radial extent, viewing and taking samples as it approached the cloudtops of Saturn.

In this month's advanced-concept study, a mission to Neptune, once again nuclear-electric propulsion (NEP) is the choice. Kerry Nock, supervisor of JPL's Advanced Projects Group, described the mission for *Spaceflight*.

The primary advantage of NEP for the Saturn mission is the close approach it would allow to the rings. For Neptune, it is the reduced flight time from this continuously-thrusting system that makes it so attractive. Recently a study was conducted at JPL of a standard chemical-propulsion mission to Neptune which would be launched in 1991 using a Galileo-derived craft. Even with a swingby of Jupiter for gravity assist, the time to Neptune would be 20.5 years. An NEP system, which expels mercury ions to provide a low level of thrust over long periods, could reduce the time to Neptune by 8 to 10 years.

The Neptune-Orbiter trip begins with a Shuttle launch that carries the probe to a high orbit of 700 km for reasons of nuclear safety. After the NEP system is released from the cargo bay and the Shuttle has moved to a safe distance, the nuclear reactor starts up.

The low, continuous thrust contrasts with the high thrust, short burn provided by a classical rocket such as the Centaur; it requires about 430 days of NEP thrusting before the probe has escaped from the Earth and entered the domain of the Sun's gravity, some 1,250,000 km from Earth, or three times the distance between the Earth and its Moon.

One disadvantage of the long, slow spiral from Earth is the relatively long time that must be spent crossing the Van Allen radiation belts. The bombardment of high-energy protons could prove harmful to the equipment but calculations show that the exposure is about equal to that which JPL's Galileo will face in the Jovian radiation belts. Therefore, the radiation shielding problem, which has been solved for Galileo can also be overcome for the Neptune mission.

After escape from Earth the engines continue their thrusting until 1538 days after launch. Solar System escape velocity is actually achieved 250 days before this cut off. During the Earth spiral escape periodic calibrations of the scientific instruments are required; the ion thrusters will be turned off to provide a clean, uncontaminated environment.

More than five additional years are spent with the engines off as the probe rushes towards Neptune on a trajectory which, if unchecked, would carry it out of the Solar System forever.

At 3400 days (9 yr 4 mth) the thrusters are again turned on and the craft is slowed by a spiral capture orbit into the vicinity of Neptune. This phase requires about 65 days. Analysis has shown that an even better method of entering the Neptunian system is to use a gravity assist from the massive satellite, Triton; gravity assists are useful in slowing down spacecraft as well as speeding them on their way. Triton would be approached at a height of 1000 km, thereby placing the probe into an elliptical orbit about Neptune with a period of 40 days. Further re-encounters with Triton can be used to bring the orbiter even closer to Neptune.

Before the Triton encounter, a probe would have been released in order to plunge into the planet's atmosphere (after a 150 day flight) and obtain information about the physical and chemical properties of that atmosphere.

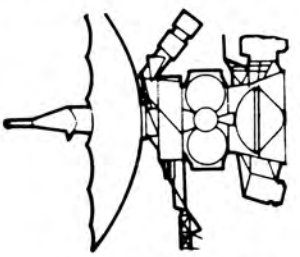
The delivery of this 950 kg payload (the probe has a mass of 275 kg) into an orbit about Neptune would be a valuable follow-on early in the next century to the 1989 reconnaissance by Voyager 2. The payload would include an imaging system (Neptune receives only 1/900 the solar energy that the Earth does, so long exposure times would be necessary), infrared spectrometer, UV spectrometer, photopolarimeter, dust analyser, and instruments to measure the field and particle environment.

THE BRAIN OF GALILEO

The finger of the astronomer Galileo is preserved in a museum in Florence for the curious to see: a sort of secular relic. The "brain" of the Galileo spacecraft is an onboard computer now entering its final stages of fabrication and testing at JPL.

This computer, called the Command and Data System (CDS), performs two vital jobs for the craft, scheduled for launch in 1986 for its orbital mission about Jupiter: (1) it sorts the commands received from the ground and sends them on to the appropriate subsystem; (2) it collects data from all of the instruments, formats these data, and passes them for delivery to Earth.

Technically, this is all carried out by six microprocessors and a 176,000 byte random-access memory. The system is radiation hardened for survival in the harsh Jovian environment.



One of the ways that the Galileo CDS differs from its predecessor on Voyager is that it distributes its "intelligence" over several sites on the spacecraft rather than concentrating it all in one place. In particular, the instruments which gather the scientific data have been made relatively "smart" and can understand terse instructions passed on by the CDS. On previous spacecraft, the instruments had to have all commands spelled out in exquisite detail for them before they could respond in the desired fashion by pointing at a target, for example.

The first CDS flight unit, delivered in May, is being used for system testing and then will be fitted aboard Galileo. The second flight unit will be delivered at the end of the year and used as a backup. If not needed in this capacity, it would be passed on to a subsequent project, with the Venus Radar Mapper being the most likely. In an era of tight budgets, JPL must treat the modern Galileo's parts as carefully as those of the historical Galileo have been treated elsewhere!

T 32

JAPAN'S HALLEY'S COMET PROBES

By Neil W. Davis

Introduction

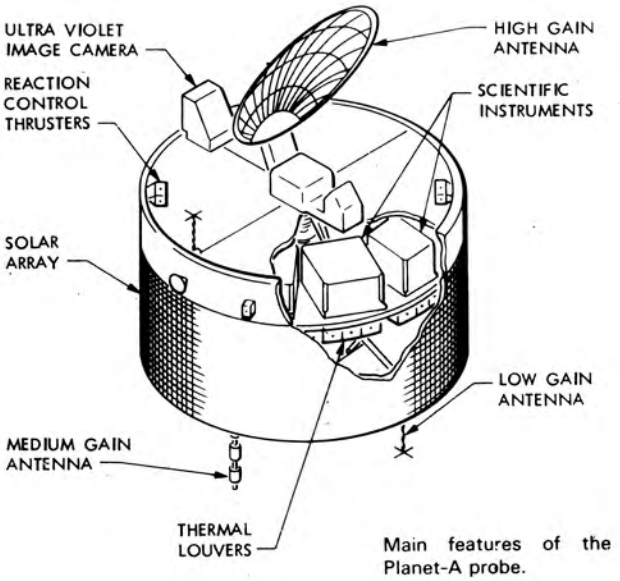
Halley's Comet will make its next flyby of the Sun in early 1986. Several spacecraft, including the Japanese Planet-A, will approach the streaking comet on the far side of the Sun to provide the first close up views of the celestial visitor. An experimental version of Planet-A, the pathfinding "MS-T5", will be Japan's first deep space mission, launched eight months before the main probe. Japan's Institute of Space and Astronautical Science (ISAS) has scheduled the launch of Planet-A for 14 August 1985 from the ISAS Kagoshima Space Center in Uchinoura, Kagoshima Prefecture.

Planet-A will be a spin-stabilised probe featuring Charge Coupled Device (CCD) scanning instrumentation. On 8 March 1986 it will make its closest approach to the comet, approximately one month following Halley's 9 February 1986 perihelion passage.

MS-T5 will be launched from the Kagoshima centre on 31 December 1984 (Universal Time). Both spacecraft are being built by Nippon Electric Co. (NEC) in Yokohama, under the direction of ISAS.

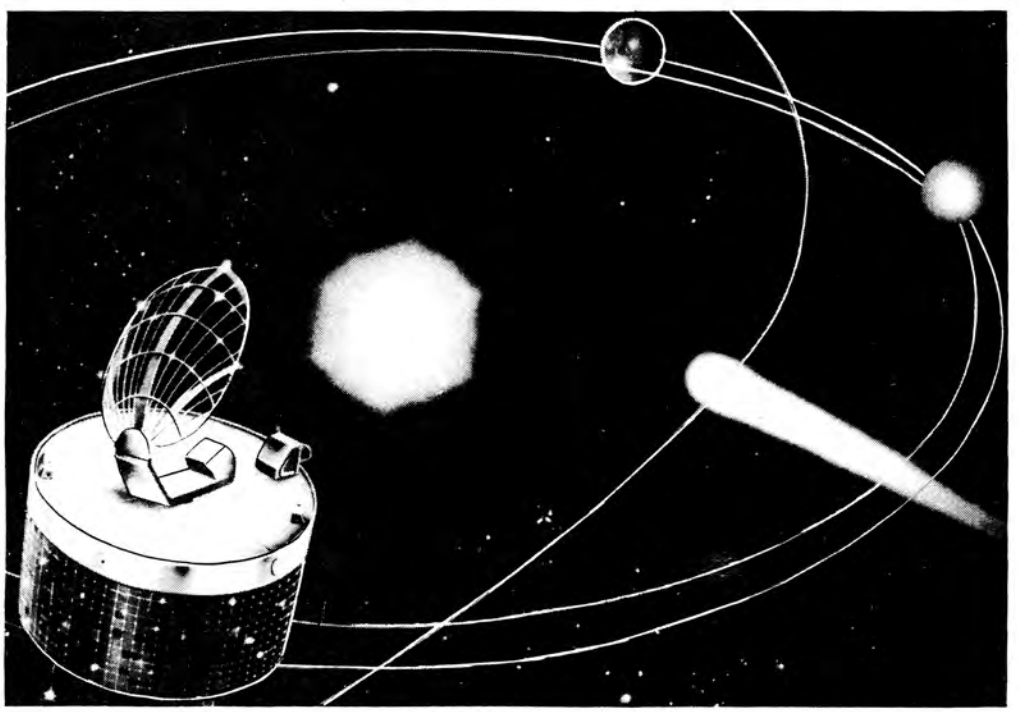
The main scientific objective of Planet-A is to make ultraviolet observations of the comet during the immediate post-perihelion phase, when activity is expected to be at a peak. Closest approach will be 150,000 km. Over the course of about six weeks, mainly in the post-perihelion phase, the probe will take a series of pictures of the growth and decay of the hydrogen cloud around the comet's nucleus (formed by the photodissociation of hydrogen within the nucleus).

Scientists at the Komaba-Tokyo ISAS Laboratories will also study the influence of the solar wind on the comet. Investigation of the interaction between the on-coming solar wind and the comet's plasma tail is planned as one of the main objectives of the two Japanese probes. MS-T5 will observe the magnetic field of the solar wind, plasma waves, and solar wind particles in the area "downstream" of the comet relative to the Sun. Planet-A will concentrate on actual comet observations.



Main features of the Planet-A probe.

The two spacecraft will be launched by a four-stage solid propellant rocket: the deep space version of the "Mu-3SII" launcher. Each of the four stages uses polybutadiene propellant, and two strap-on boosters will be carried. The standard three-stage version is



Planet-A and the orbits of Halley's Comet and Earth.

ISAS

capable of injecting a 700 kg satellite into a low Earth orbit. The launch weight of Planet-A's vehicle is 62 tonnes. The manufacturer is the aerospace division of Nissan Motors (Nissan-Datsun motorcars).

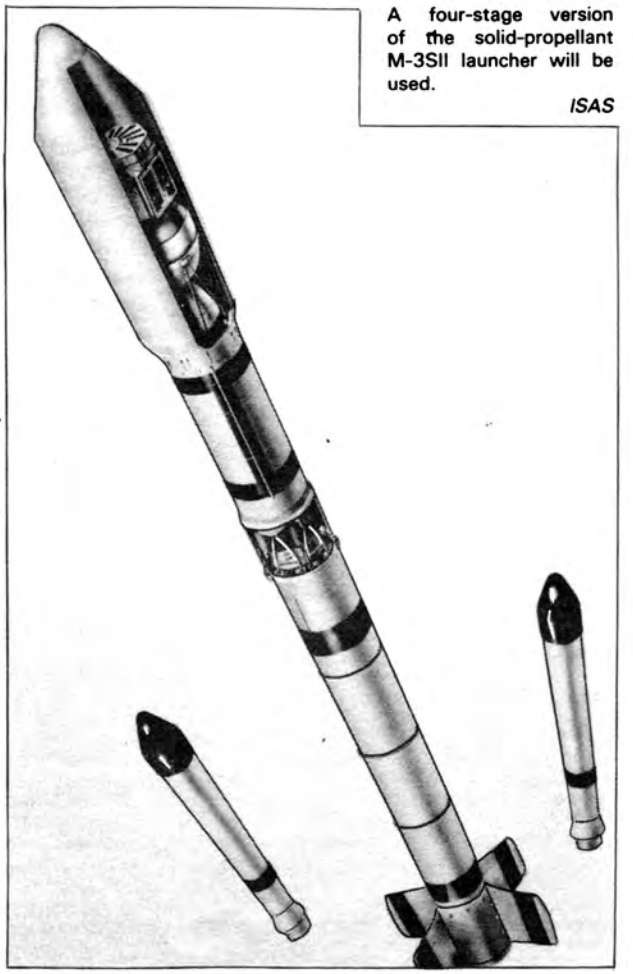
A 64 m deep space dish antenna is now under construction at Usuda, Nagano Prefecture, for the Tracking, Telemetry and Command (TT&C) of these and subsequent ISAS planetary probes. This TT&C antenna is being built by Mitsubishi Electric in the "radio-quiet" Nagano valley approximately 170 km northwest of Tokyo.

The Spacecraft

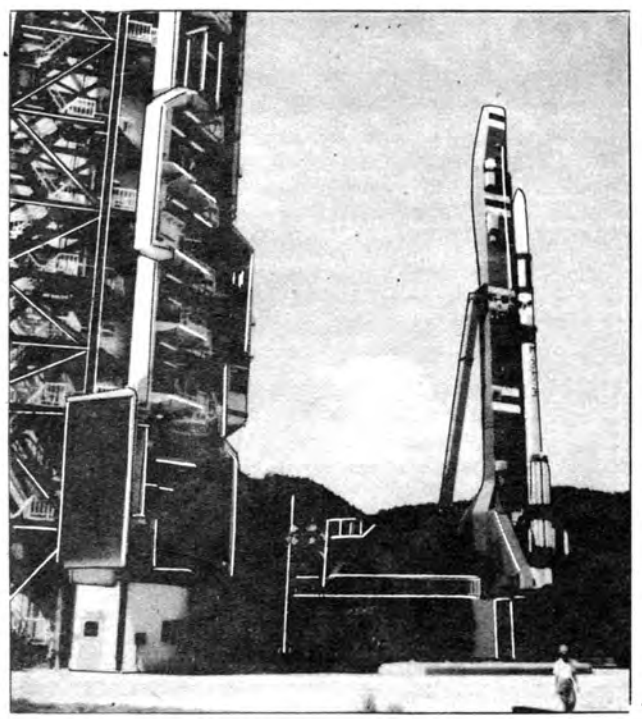
The spin-stabilised Planet-A is cylindrical, with a 1.4 m diameter and a height of 0.7 m. MS-T5 has the same measurements and will weigh 141 kg; one or two kg heavier than its successor. ISAS decided on a spin-stabilised design in order to avoid the problems of thermal control inherent in three-axis control spacecraft. Planet-A will feature an ultraviolet telescopic mirror lens and image-detecting CCD scanners. During its cruise, the spin-rate will be set at 5 r.p.m.; at the time of imaging the rate will be decreased to 0.5 r.p.m. The image data will be stored in magnetic bubble memory recorders and transmitted to the ISAS deep space centre after completion of the imaging cycle. While imaging of the comet is underway, Planet-A will be stabilised by a bias momentum wheel.

Both probes will use offset parabolic reflector high gain S-band antennae with medium-gain backup antennae. The 80 cm diameter high gain antennae are mounted on despin motor assemblies.

The two spacecraft will be injected directly into heliocentric orbits, without the use of Earth-parking orbits, in order to reduce the complexity and weight of the attitude control systems. Planet-A's orbit will have a perigee of 0.68 AU and an apogee of 1.0 AU. MS-T5's orbit has yet to be finalised; it may be directed to take the probe into the comet's ion tail. Fortunately, the launch windows conveniently fit the ISAS launch schedule which is determined by the powerful fishermen's union in the area (launches mean that the sea area has to be cleared for safety). Both ISAS and the National Space Development Agency (NASDA) have to undergo negotiations with the union for any transgressions of these windows. Planet-A is scheduled for launch near the beginning of its launch window (lasting 20 days and extending into early September) because typhoons occasionally disrupt the Kagoshima and Tanegashima schedules in the August-September "fisherman launch window."



A four-stage version of the solid-propellant M-3SII launcher will be used.
ISAS



An M-3S launcher on the pad at ISAS's Kagoshima Space Center.
Neil Davis

Before Planet-A's imaging cycle of the comet's hydrogen cloud can begin, an intricate series of manoeuvres must be made. For five hours after fourth stage firing the trajectory will not be accurately known. After re-tracking is completed, the spin-rate is reduced from 120 to 5 r.p.m. Next, the probe's attitude is stabilised to be perpendicular to the ecliptic plane. An initial course correction will then be made on the basis of the first three days of ranging and orbital analysis. This correction will be made by spin-synchronised pulse jets, ensuring that the attitude remains normal to the ecliptic. Attitude control manoeuvres will be made

Japan's Halley's Comet Probes/contd.

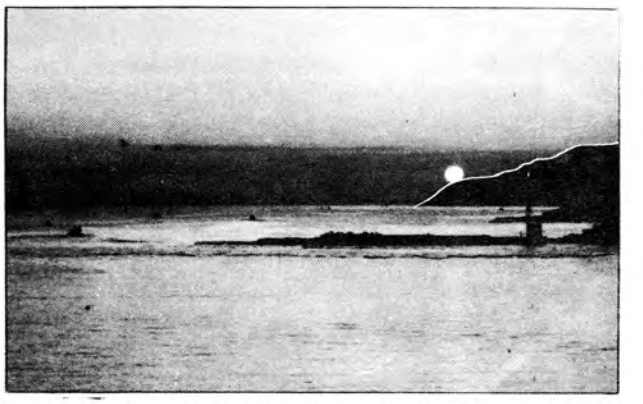
about every 10 days.

Approximately 2000 solar cells, of 2×6 cm and smaller, will be installed on the cylindrical body.

Planet-A will carry charged particle detectors for investigating the three dimensional distribution of the solar wind near the ecliptic plane. MS-T5 will carry a different package: ion temperature, ion velocity, plasma density, and electron temperature will be monitored.

Both missions are under the supervision of Professor K. Hirao of the Planetary Science research division at the ISAS Komaba-Tokyo Laboratories. These missions will begin the new era of deep space exploration for Japanese scientists. ISAS scientists are currently developing planetary probes and even an "OPEN-Japan" plasma-detection spacecraft for NASA's OPEN project (Origins of Plasma in Earth's Neighborhood, a four-spacecraft NASA project).

With the construction of the large TT&C communications centre in Nagano, ISAS is preparing to assist in maintaining deep space communications with American and European spacecraft. The Komaba-Tokyo ISAS Laboratories have been participating with European and Soviet scientists in the international Halley's Comet investigations.



Sunrise over the Kagoshima launch site, while the fishermen practise their ancient craft.

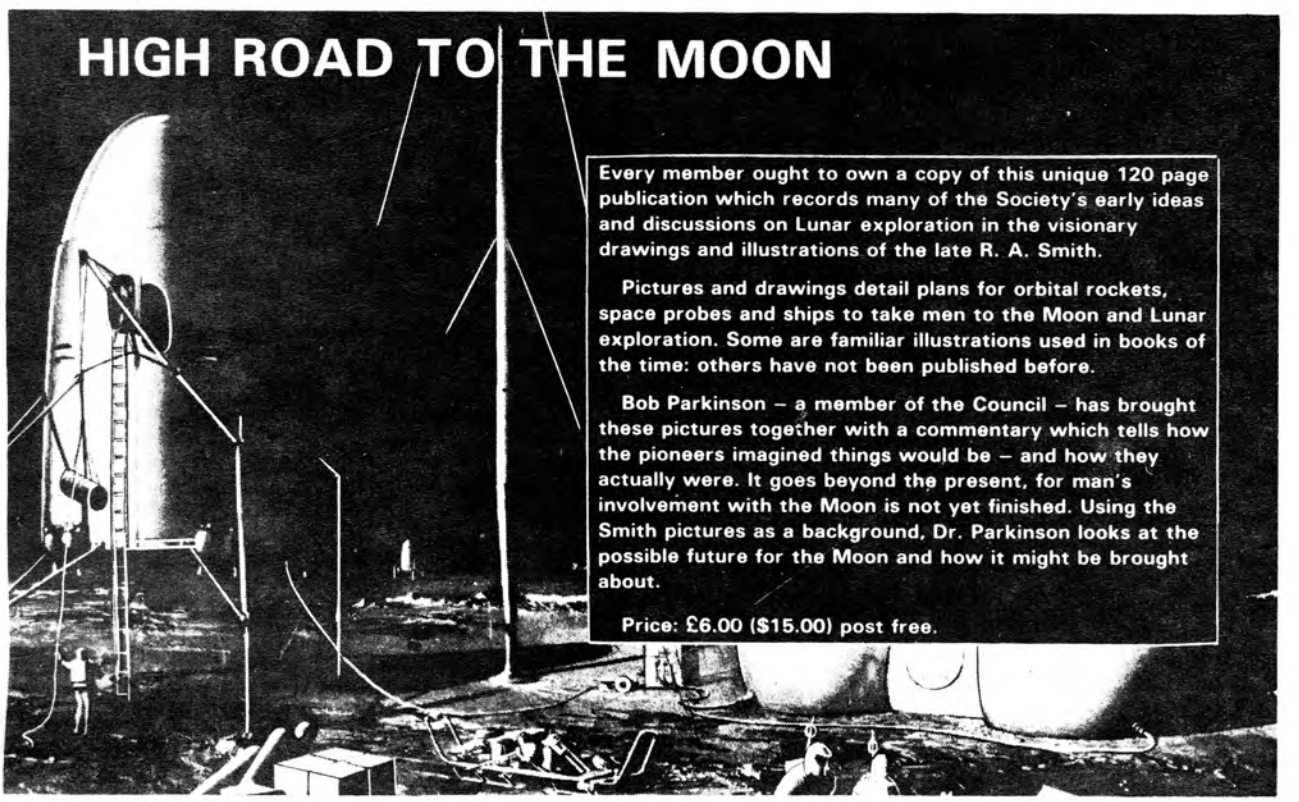
Neil Davis

Other Japanese Space Ventures

Beginning in the early-1990's, it is likely that ISAS will use the launching services of NASDA for their deep space missions. NASDA is the separate space applications organisation (in Japan's Science and Technology Agency) which launches US Delta-based "N-series" launch vehicles from its Tanegashima Space Centre (about 100 km south of the ISAS Kagoshima centre). Rather than advising ISAS to develop a new series of launchers with improved deep space capability, the Space Activities Commission of Japan (the highest space advisory body) has recommended that they use NASDA's "H-1A" and subsequent "H-series" for deep space and heavy Earth-orbit missions. The proposed "OPEN-Japan" (or OPEN-J) spacecraft will most likely be too massive for the H-series vehicle, so the US Space Shuttle will probably be used in the late 1980's.

Conclusions

Despite the fact that ISAS possesses a rather modest launch vehicle, and no experience of deep space missions, the organisation was ambitious enough to plan a Halley's Comet probe. Their whole budget is less than 2 per cent that of NASA's.


HIGH ROAD TO THE MOON
Every member ought to own a copy of this unique 120 page publication which records many of the Society's early ideas and discussions on Lunar exploration in the visionary drawings and illustrations of the late R. A. Smith.
Pictures and drawings detail plans for orbital rockets, space probes and ships to take men to the Moon and Lunar exploration. Some are familiar illustrations used in books of the time: others have not been published before.
Bob Parkinson – a member of the Council – has brought these pictures together with a commentary which tells how the pioneers imagined things would be – and how they actually were. It goes beyond the present, for man's involvement with the Moon is not yet finished. Using the Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.
Price: £6.00 ($15.00) post free.

JOHN YOUNG
– ONE MAN'S CONQUEST OF SPACE

By David J. Shayler

Continued from the May issue.

The first three parts of this series followed the veteran astronaut's career from his early days to the planning stages for Gemini 10 in 1966. Part 4 covers that mission.

Gemini 10 Preparations

Gemini 10 was planned for a July 1966 launch and would feature a rendezvous and docking with an Agena target vehicle during the three day mission. It was not long before this plan was expanded to cover postponed objectives from earlier missions. Gemini 6 had lost its Agena in a launch mishap, Gemini 8 was forced to come home early, then Gemini 9 lost both its Agena and the full use of the substitute docking target. With only three flights left, NASA still had to complete a fully successful rendezvous and docking.

Gemini 10 would dock with its own Agena, use the main engine to boost the combination to a higher orbit, and then return to rendezvous with the abandoned Gemini 8 Agena.

When Young learned of this plan he thought "... they (the flight planners) must be out of their minds." He was concerned about the possibly unstable Agena 8. The dual plan came into effect on 18 May, leaving little time to rehearse procedures. Young was worried about relying on visual sightings on approaching Agena 8 since they would still be docked to Agena 10, rendering their rendezvous radar useless useless [1].

EVA was also now added: Mike Collins would retrieve packages from both Gemini and Agena 10. Then, using a hand-held "zip-gun", he would visit the unstable Agena 8.

The plan now included rendezvous attempts with two Agena's in different orbits, two completely different EVAs, 15 experiments and trials with a new computer program. The crew asked for an extension to a four day flight but were turned down.

Return to Orbit

The two men eased into the cramped confines of their capsule on the afternoon of 18 July 1966, and the hatches were sealed. Some 20 minutes later they listened to their Agena target vehicle take off towards orbit. At 17:20:20 EDT Gemini 10 shook itself free of Earth and carried Young to space for his second visit. The Titan II put Gemini into an 161X270 km orbit, some 1,800 km behind Agena.

The first four orbits saw the crew racing to catch up with Agena. Troubles with the new navigation equipment and the attempt to conserve fuel plagued the manoevures but they completed a rendezvous and then docked 5 hr 53 min after launch. Owing to the heavy fuel usage the planned redocking was cancelled. This prompted Young to wonder if the Agena 8 rendezvous would also be cut .

Young (right) and Collins (second from left) inspect their Gemini 10 capsule.

NASA

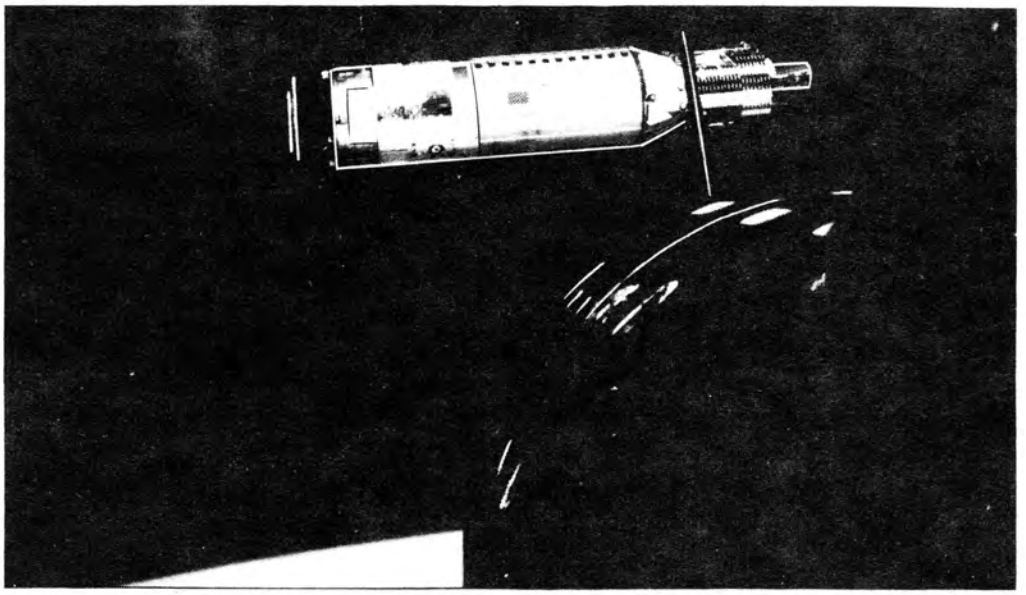
It was not. At 7 hr 39 min the crew ignited Agena's engine and were pushed, backwards, up to a higher orbit. Young later described the burn [2]:

"Mike threw the switch and one minute and 20 seconds later, it was really something. At first the sensation I got was that there was a 'pop' in front of my eyes, then there was a big explosion and a clang. We were thrown forward in our seats, against our seat harnesses. Fire and sparks were coming out of the back of that rascal. The light was something fierce and the acceleration was pretty good."

Young and Collins had reached a new orbit of 294X763 km, almost twice as high as any other human.

The Second Day

After some nine hours' sleep the crew were ready to begin a hectic day. They fired Agena's engine again to bring the apogee down to some 17 km below the orbit of Agena 8. Mike Collins opened his hatch during a night pass and for 33 minutes operated the Ultra



Young slowly approaches the Agena 10 docking vehicle. The main rocket motor is on the right hand side; at left is the docking collar.

NASA

Violet Camera experiment, scanning the Southern Milky Way and exposing 22 frames.

Throughout the second day the crew fitted in several of the 14 experiments and continued the usual housekeeping jobs. Collins began preparations for his tethered EVA the next day while Young busied himself with perparations for the final manoeuvres needed to reach Agena 8.

The Third Day

Early on day 3 Young and Collins made two manoeuvres to reach their Agena 8 target. The combination was then on the correct path for rendezvous with Agena 8. Young now undocked from Agena 10 to go it alone.

During the chase, Collins prepared for his EVA. Young sighted the Agena and he started the final run in while Collins computed the figures for the two mid-course corrections. The old Agena was stable and Gemini was soon flying some 3 m above it. Young had completed the most difficult phase of the mission, this time with fuel in hand.

Space Walking

Some 41 minutes later Collins again opened his hatch. In Mission Control they were watching the fuel levels and sent up a go-ahead for the the EVA to start. "Glad you said that. ." Young replied, "because Mike's going outside right now!"

Over the next 39 minutes Collins recovered experiments from both Gemini and Agena 8. Young carefully maintained the proper attitude, guided by Collins, and flying as close as he could alongside the old target vehicle, carefully not firing the thrusters near his colleague.

With the major objectives achieved, Mission Control advised Young to end the EVA to conserve the remaining fuel. "Well then, he'd better get back in," he replied. He told Collins, "Come back in the house".

The two men struggled with the 50ft (15 m) umbilical and the bulky EVA suit for several minutes before finally shutting the hatch. In the middle of it all the ground requested Young to relay a propellent reading from a console he could not find let alone see. "Get serious," he replied. As they fought to put all the unwanted equipment into bag to dump overboard, it all reminded Young of "a snake-house at the Zoo."

A little over an hour later Collins again opened his hatch to throw out the unwanted equipment. With the extra room Young was finally able to stretch his legs.

Re-Entry (Fourth Day)

Retro-fire came at 70 hr 10 min into the mission, the four retromotors slowing the craft down as it arced towards the Earth and its water landing. "That was a superfine automatic retrofire," Young commented.

During reentry Young steered the craft in banking angles using the computer and onboard thrusters. Waiting for the parachutes, Young, remembering his experience on Gemini 3, warned Collins to brace himself. Both waited with arms over the panel in front of their faces for the expected pitch forward. However, as the 'chute changed position, the craft just swung gently. Splashdown came gently after a flight of 70 hr 46 min on 21 July 1966, only some 5.4 km from the planned landing point.

Young now moved on to a new phase of his astronaut career. Gemini was nearing completion and Apollo was just over the horizon. Young, like most of his fellow astronauts, hoped his next flight would take him to the Moon.

To be continued

Acknowledgements

As listed in Part 1 of this series.

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SATELLITES SAVING LIVES

WEATHER SATELLITES AND STORM WARNINGS IN BANGLADESH

By Dr. A. M. Choudhury*

Bangladesh is a part of the humid tropics, with the Himalayas in the north and a funnel-shaped coastline touching the Bay of Bengal in the south. This peculiar geography gives rise to the life-giving monsoons but also causes catastrophic cyclones, norwesters, tornadoes and floods, all of which can cause immense damage and loss of life. Using satellites, new techniques are being developed to try to alleviate the amount of misery and destruction they bring.

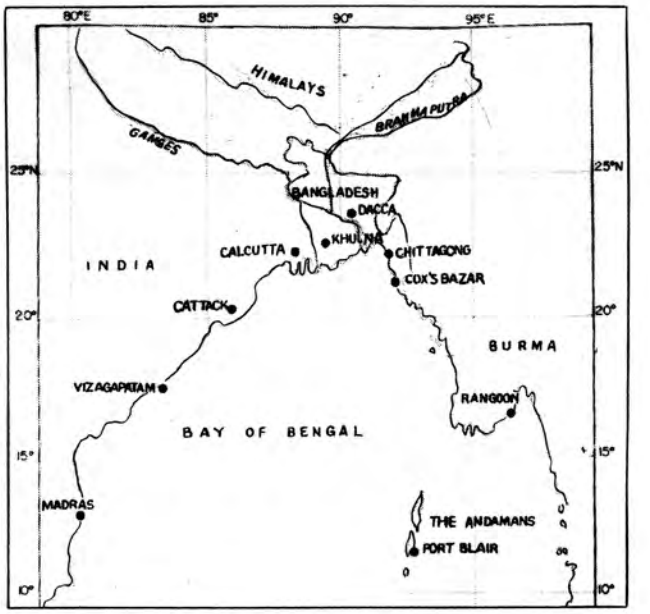
Bay of Bengal Cyclones

Because of its funnel-shaped coast, Bangladesh very often becomes the landing ground of cyclones formed in the Bay of Bengal. These cyclones also move towards the eastern coast of India and towards Burma, but they cause the most damage when they come into Bangladesh, because of the low flat terrain, high density of population and poorly built houses. Most of the damage occurs in the coastal districts and in the off-shore islands.

Of all the terrible cyclones that have hit Bangladesh, perhaps the most deadly was that of 12 November 1970. It caused indescribable human misery. Officially a figure of 500,000 deaths is given, but in reality it could be more. Nearly 90 per cent of the off-shore fishermen suffered heavy losses [1]. It is estimated that some 46,000 inland fishermen lost their lives and 9,000 fishing boats were destroyed. The damage to property and crops was colossal. The estimated maximum wind speed was about 140 m.p.h. (224 kph) and the maximum storm surge height about 30 ft (9 m). The cyclone occured during a high tide period and hence the great surge height.

Though records of cyclonic storms affecting Bangladesh in the past are available, they do not give as full a story as today's weather satellites. There is a record in Ain-E-Akbari of a great storm in 1584 which affected the district of Barisal. Another great storm in October 1876 is recorded which affected the coastal districts of Barisal, Noakhali and Chittagong. The storm surge due to this cyclone was thought to be about 40 ft (12 m). About 200,000 people died; and perhaps more from the after-effects, such as epidemic and famine. No relief reached them for months. Considering the population at that time, a loss of life of 200,000 was tremendous.

The great cyclone of 1919 also deserves mention. It originated in the Pacific about 4,000 miles (6,400 km) away and it took some 20 days to reach the coast of Bangladesh. Records show [2] that from 1891 to 1981,



The Bay of Bengal and surrounding countries.

166 severe cyclones (wind speed more than 54 m.p.h. 86 kph) were formed in the Bay of Bengal. It is apparent that such cyclones occur mostly during pre (April–May) and post (September–December) monsoon periods; they are the ones that cause most destruction.

Advantages of Space Meteorology

The distribution of surface weather observations is heavily biased towards well-populated land regions. Commercial shipping does provide some observations over the oceans, but since ships avoid cyclones, the most vital data are lost. With the advent of the space age, satellites can survey the Earth's weather from a point well above the surface. Other advantages of space meteorology over conventional methods are:

1. Spatial continuity: the observations are horizontally continuous; this eliminates interpolation and thus the ambiguity often present in synoptic charts.

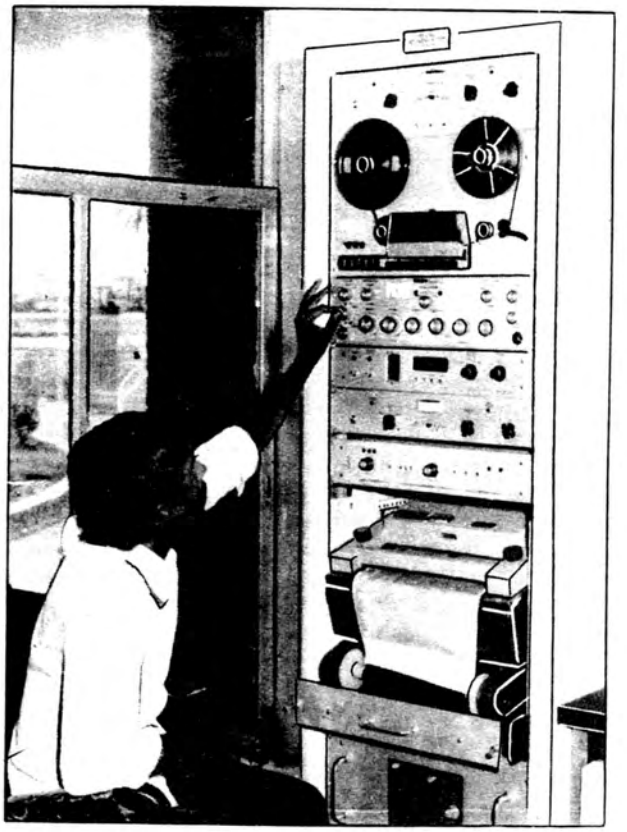
2. Information is on a synoptic scale with virtually no time lag.

3. Visual integration: permits integrated visualisation of weather systems in a way readily acceptable to the human mind.

4. Independence of communication systems: provides large-scale weather information even if the normal system of communications has broken down.

Space Meteorology does not make traditional synoptic meteorology obsolete: rather it supplements the

* *Director (Research) of Bangladesh Space Research and Remote Sensing Organisation (SPARRSO), Agargaon, Sher-E-Bangla Nagar, Dacca, Bangladesh.*



SPARRSO Weather Satellite Ground Station in operation.

old system to which improvements and innovations are continually taking place.

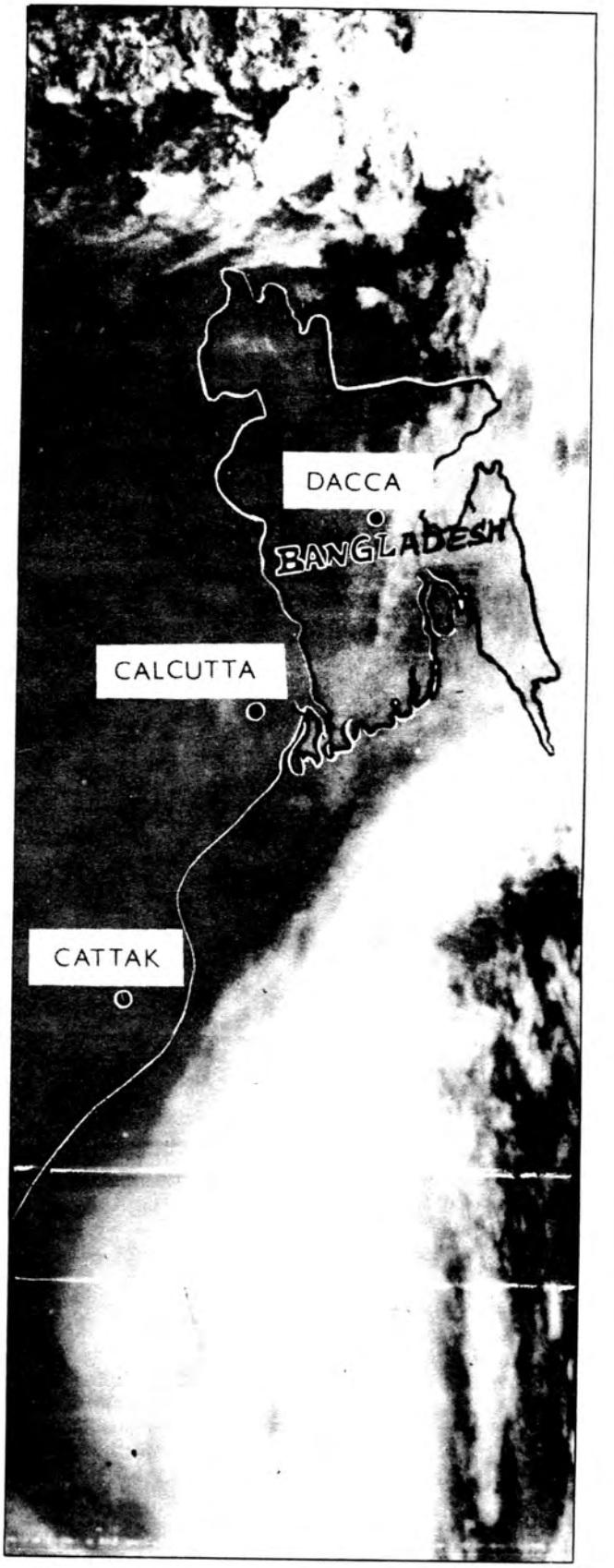
Weather satellites

Bangladesh does not have either rocket or satellite facilities of its own but with the help of ground stations we can receive pictures from weather satellites launched by others.

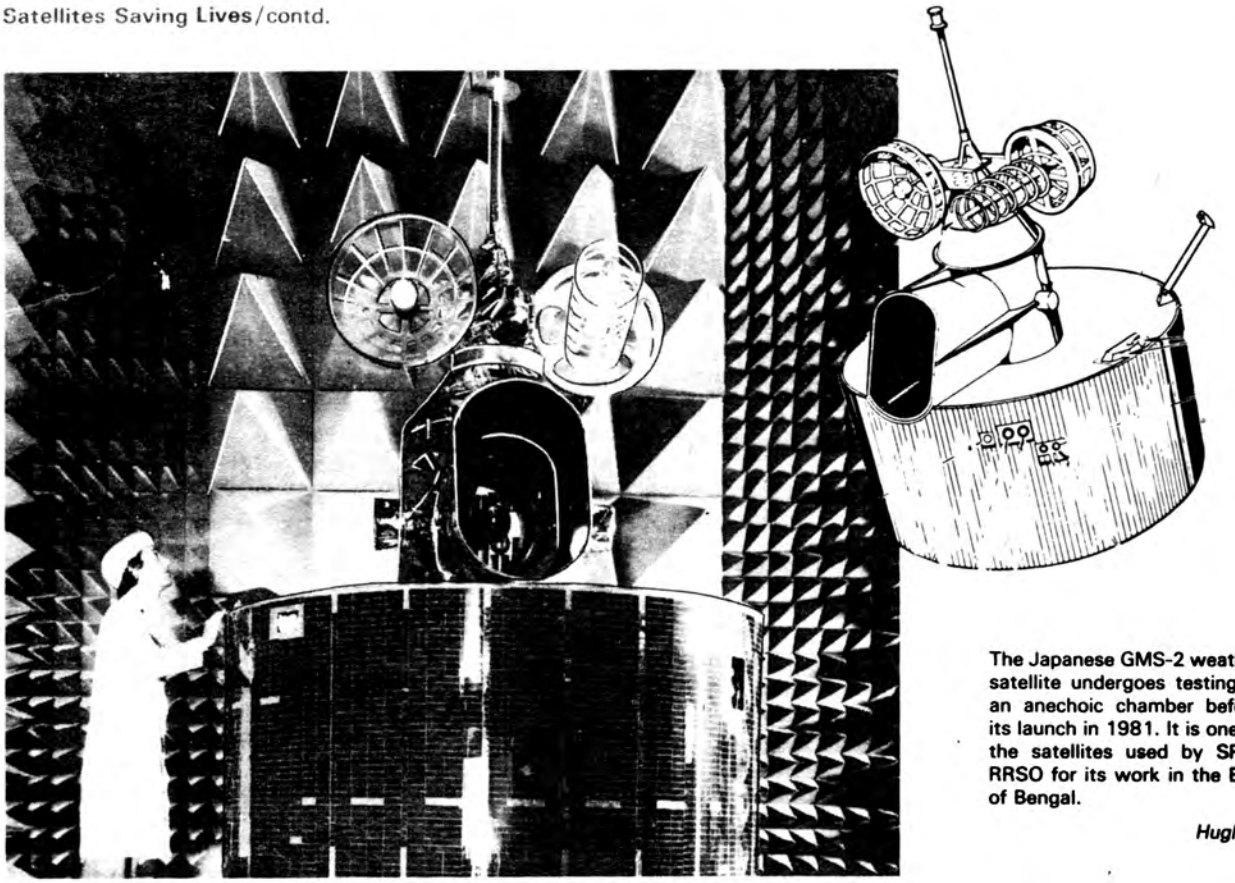
An APT (Automatic Picture Transmission) Ground Station for the reception of imagery from weather satellites was established in 1968. This has detected and tracked all cyclones formed in the Bay of Bengal since then. Because of this equipment, no cyclone in the Bay escapes our notice. Presently we can receive pictures from the US NOAA-7, Japanese GMS-2 and USSR Meteor satellites. We can detect the cyclones, track their motion and predict their future movements. From the organisation of the cloud patterns, we can deduce wind speeds in cyclones. Theories are being developed for accurately predicting cyclone movement [3].

Estimation of Storm Surge Heights

In addition to the ocean waves generated by winds, abrupt surges of water are associated with cyclones. They strike the coast nearly at the same time as the centre of the storm crosses the coast. The surge is further amplified if it coincides with normal diurnal high tide. Surge heights have been reported as high as 40 ft (12 m). Most of the damage due to cyclones is done by their storm surges, which sometimes wash over



A tropical cyclone of hurricane intensity in the Bay of Bengal detected by NOAA-6 on 3 May 1982 and received at the Ground Station of SPARRSO. The eye of the cyclone is clearly visible at bottom.



The Japanese GMS-2 weather satellite undergoes testing in an anechoic chamber before its launch in 1981. It is one of the satellites used by SPARRSO for its work in the Bay of Bengal.

Hughes

whole islands and coastal areas. Thus accurate prediction of surge height is essential in order to take proper protective measures.

Surge heights are dependent on the shape and size of the bay, the track of the cyclone and the wind speed. To calculate them is extremely difficult. In model calculations, idealised conditions are assumed and, as a result, prediction does not always agree well with observation. Also, the track of the cyclone cannot be accurately forecast much ahead in time. In Bangladesh, if the cyclone crosses along the Patuakhali Coast, the surge height is more than if it crosses along the Chittagong Coast. Moreover, as the wind in cyclones moves in an anticlockwise direction, the surge is more pronounced on the right-hand side of the track than on the left.

A preliminary model of storm surge heights corresponding to various wind speeds in cyclones has been prepared [4]. A detailed numerical model is under development.

Tornadoes

Another kind of storm very similar to a tropical cyclone but of much smaller dimensions and very destructive is the tornado. It is also a low pressure region where strong winds blow around a centre (in an anticlockwise direction in the northern hemisphere, clockwise in the southern) but, unlike a cyclone, it develops on land. A cyclone lasts for days whereas a tornado has a very short duration, although it is very destructive.

The horizontal diameter varies from a few feet up to a maximum of one mile (1½ km). The pressure at the centre is much lower than that of the surroundings and the air at the centre rises rapidly.

Since the horizontal diameter is so small and forms so suddenly it is difficult to recognise a tornado either in a surface weather map or in a satellite picture; hence forecasting a tornado well ahead of its occurrence is very difficult. Moreover, satellite pictures are obtained in the morning whereas tornadoes occur in the afternoon. Certain cloud features and some surface characteristics may indicate the occurrence of a tornado, but it is very difficult to pinpoint the place and time it will strike [5].

Bangladesh now has a comprehensive Cyclone Preparedness Programme, operated by some 20,000 volunteers. Once a dangerous situation has been detected *via* one of the weather satellites the Programme swings into operation to bring relief to affected areas. Since 1970, there has clearly been a sharp decrease in cyclone-related deaths; a reduction due to the introduction of satellite technology.

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T 40 LIGHTNING RESEARCH FROM SPACE

By Joel W. Powell

A little known but fascinating area of space science is the study of lightning from space. Terrestrial lightning, as well as lightning in the atmospheres of the planets Venus, Jupiter and Saturn, has been studied by a variety of spacecraft over the past 15 years.

Introduction

In the course of research with an ultraviolet spectrometer aboard NASA's Orbiting Solar Observatory 2 satellite it was discovered almost by accident that lightning could be seen from orbit. It had been previously believed that satellite photometers were not sensitive enough to detect such effects [1]. Detection was often hampered by reflected Sunlight or Moonlight (which tends to saturate the optics).

It was evident that more flashes occurred over land than over the oceans. Further information was sought when an ultraviolet spectrometer was again flown on OSO 5, launched on 22 January 1969. The data from the six photometers were searched for lightning events, and about 1,000 storm systems and over 7,000 strokes of lightning were detected. Results were consistent with those from OSO 2 [2].

Two years after OSO 2, the first dedicated lightning experiment was flown on the UK Ariel 3 satellite. Aimed at measuring radio rather than optical output from lightning, the Terrestrial Radio Noise experiment enabled scientists to locate thunderstorms on Earth [3].

A NASA U-2 aircraft recorded seven simultaneous lightning bolts during an overflight of a thunderhead in May 1982.

In the mid-1970's the Japanese conducted a similar experiment on their two Ionospheric Sounding Satellites. Each carried the Radio Noise Measurement experiment, which included a four channel receiver operating at 2.5, 5, 10 and 25 MHz. These frequencies are difficult to study due to low signal strength and man-made radio interference. Radio noise from lightning, called "sferics" or "atmospherics", was recorded by the apparatus so that the experimenters could learn to discriminate between lightning and artificial emanations; the rate of emission was also plotted [4,5].

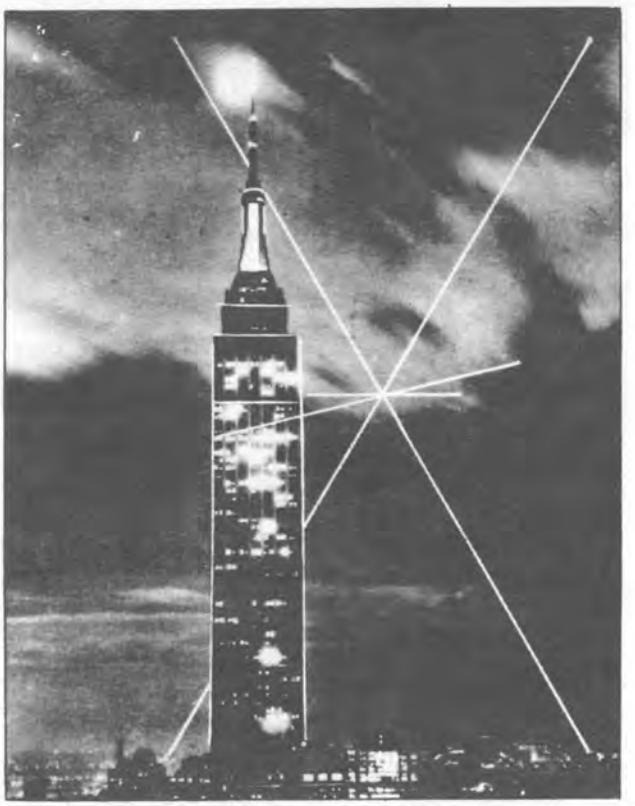
The high-altitude Radio Astronomical Explorer 1 satellite (Explorer 38), also recorded radio emission as part of its observations of radio sources from the Earth. Ionospheric absorption shielded much of the lightning-generated radio noise but enough reached RAE-1's distinctive 228 m dipole antenna for thunderstorm activity to be mapped [6].

Lightning and Vela

Orbiting at a distance of over 100,000 km, the Vela satellites monitor the Earth for signs of clandestine nuclear explosions. From their lofty positions, they were also able to record optical and radio emission from lightning. Vela 4B, launched in April 1967, carried a Very Low Frequency (VLF) radio receiver among its host of blast detection instruments. Included in the VLF signals received, at the selected frequencies of 28, 34 and 42 MHz, were "atmospherics" generated by lightning activity. The data allowed the location of thunderstorms to be plotted [7].

For optical detection of nuclear blasts, each of the six advanced Velas (other pairs were launched in 1969 and 1970) carried three wideband silicon photo-diodes. Operating in the 400-1100 nanometre range, a minimum pulse of 10^{11} watts was required to trigger the detectors. Unusual background signals were noted and researchers soon recognised that the tracings were due to lightning [8]. By 1972 a correlation was made between the Vela optical observations and "atmospherics" measurements from the ground-based VLF radio network of the US Air Force [9]. Analysing the optical data, researchers under Capt. Bobby N. Turman of the USAF noted that some of the recorded pulses, less than 1 per cent of the total, reached unusually high energy levels exceeding 3×10^{12} W. With lightning discharges averaging 10^{10} W, Turman's group realised that they had discovered a new form of lightning, which they promptly dubbed "superbolts"[10]. Such energetic outbursts had never before been seen. [11].

The vast majority of superbolt sightings were associated with winter storms over the Pacific Ocean east of Japan, an area long known for unusually intense lightning displays. Capt. Turman theorised that they were caused by discharges between positively charged regions in storms and the ground, rather than from negative regions as in more typical summer storms. Of the thousands of lightning flashes powerful enough to



The Radio Astronomy Explorer carried antennae longer than the Empire State Building.

trigger the Vela sensors, only an average of five per year were energetic enough (100 times as powerful as regular discharges) to be called superbolts. Due to problems of viewing geometry and other factors, Turman believes that those five flashes represent only about 20 per cent of the actual total [12]. Superbolts may pose a danger to aircraft flying in the region during the winter storm season.

Piggyback Experiments

In 1974 a piggyback lightning experiment was carried on a polar orbiting military weather satellite. Called SSL (Special Sensor Lightning), the tiny 1 kg package was the first purpose-built optical space lightning instrument. It was included on the Block 5B/C Defense Meteorological Satellite Program (DMSP) Flight 33, launched on 16 March 1974. Power consumption was only 0.5 W, and the 12 silicon photo-diodes were able to view 7 million km^2 of the Earth's surface at one time. The photo-diodes were designed to trigger at an output of between 10^8 to 2×10^{10} W [13,14].

Unfortunately, the sensor was only able to gather a limited amount of data due to "conflicting operational priorities" with DMSP's other instruments. Lightning records from only 15 orbits were correlated with storm activity, for a total of about 10,000 flashes recorded from 24 storms. The sensors were also plagued by high levels of reflected Sunlight and Moonlight. However, the results were used to design a more capable piggyback experiment for Capt. Turman's group.

On one occasion in the early 1970's a DMSP spacecraft imaged lightning that was illuminating squall lines on Earth's night side. The position of the unusual streaks were matched with weather map data and it is possible that visible-light imaging of such activity may find use in storm detection and tracking systems [15].

Capt. Turman's lightning sensor was carried on the second of the new-generation Block 5D DMSP spacecraft, launched on 5 June 1977. Improved integration of the experiment with the vehicles allowed more data collection time, but operations were still severely restricted. PBE-2 (Piggyback Experiment-2) consisted of a single photo-diode able to view 2 million km^2 of the surface at one time, with four seconds being required for a discharge to be recorded. Nevertheless, world-wide mapping was carried out, revealing that lightning appears mostly over land, with a smattering over the oceans. At dawn some lightning does occur over the sea, distributed fairly evenly over the globe, but by dusk the majority of the day's activity is generated over the continents [16,17].

An improved lightning monitor was developed and flown on the next Block 5D satellite, Flight 3. Like Flight 2, it travelled in a "dawn-to-dusk" Sun-synchronous polar orbit. PBE-3 had a more sensitive "trigger time" response to help to produce a higher resolution distribution map, again verifying past results. Researchers were able to obtain "ground-truth" results for PBE-2 *via* the Thunderstorm International Project-1977 at the Kennedy Space Center in Florida; many of the flashes were simultaneously captured by TIP instruments [18].

Concurrently with the PBE-3 experiment, Capt. Turman flew a much more sophisticated lightning detector on the S77-2 Space Test Program payload launched on 16 March 1978. S77-2 was attached to a Big Bird photo-reconnaissance spacecraft. The sensor possessed a much larger optical array, with two "locaters" and a PBE-2 type sensor which allowed very accurate mapping of the discharges [19].

For his work in the space programme and lightning research in particular, Capt. Turman was presented with the 1978 Achievement Award of the 15th Annual Space Congress [20].

Future Developments

NASA has expressed interest in space lightning observation. The agency sponsored research at the University of Arizona that resulted in the design of a sensor intended for use on geostationary weather satellites. The BOLTS (Broad-area Optical Lightning Telescope Sensor) will be a sophisticated CCD (charge-coupled device) array that will permit monitoring of the entire continental United States day and night. A prototype unit is now in use on a NASA U-2 aircraft. BOLTS has yet to be assigned a launch spot [21,22].

Extraterrestrial Lightning

Soviet and US probes have discovered lightning on at least three other planets: Venus, Jupiter and Saturn. Mars, with its tremendous dust storms, is also suspected of harbouring lightning, but Viking and Mariner orbiters did not reveal any evidence of it [23].

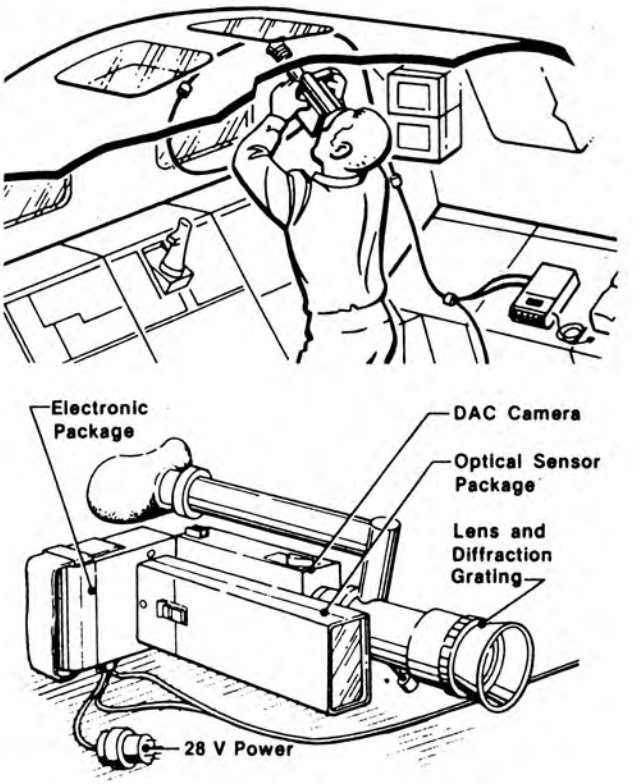
The Venera 9 and 10 spacecraft, which entered Venus orbit in 1975, were able to record lightning flashes optically with photopolarimeters. The Venera

11 and 12 landers in December 1978, however, are generally credited with the discovery of extraterrestrial lightning, by virtue of being announced first. While Venera 11 and 12 detected lightning at only two sites on the surface, Venera 9 and 10 measured activity between ±32° latitude covering an area of 35 million km² [24].

The "Groza" (Storm) atmospheric radio noise receiver on the Venera 11 and 12 landers detected emissions from lightning between 8 and 90 kHz. A search was made to determine if the discharges contribute to the production of minor atmospheric constituents. During descent the two vehicles recorded about one thousand lightning "events", with Venera 11 registering slightly more than half. On the surface, Venera 12 recorded an intense burst 30 minutes after touchdown. Attributed to "thunderstorm activity", the episode consisted of six nearly simultaneous bursts of over 100 discharges each [25]. The Venera 13 and 14 landers in March 1982 also carried the "Groza" equipment [26].

December 1978 also saw the arrival of the Pioneer Venus Orbiter at the planet. Two separate lightning investigations were conducted. First, the Electric Field Detector was used until January 1979 to record pulsed signals resembling Earthly "whistlers." Detected only when the spacecraft was at periapsis and in or near the shadow of Venus, corroborating evidence for lightning was also obtained from electron and magnetometer data [27].

The Soviet discovery of Venusian lightning led to an ingenious proposal for an optical lightning survey using the PVO star tracker. Used on orbits 300-345, when not required for navigational fixes, the sensor recorded lightning at periapsis to search for evidence of the role lightning might play in the production of trace atmospheric components. Results established an upper limit of 30 flashes per year per km², insufficient for any significant contribution to atmospheric processes. Investigation with a dedicated optical sensor could be performed on future missions to determine the precise nature and role for Venusian lightning [28].



Manned observations from orbit are now playing an important part in lightning research. This is the Shuttle NOSL experiment.

Jupiter and Saturn

Shortly after lightning was detected on Venus, the Voyager space probes extended the work to Jupiter and Saturn. Leaving Jupiter after its flyby in March 1979, Voyager 1 took a 192 second exposure of the dark side to search for aurorae and meteors. Bright spots on the image were interpreted by Allan Cook of the Smithsonian Astrophysical Observatory as being due to lightning, not unlike the "superbolts" of Earth. Investigators were unable to obtain any data to determine if complex organic molecules were being produced by the discharges [29,30].

Subsequently, evidence for lightning was also found in data from the Plasma Wave Experiment. When Voyager 1 was 5.5 to 6 Jupiter radii from the planet, low frequency "whistlers" were recorded. The extrapolation was made that the rate of lightning activity on Jupiter was about 40 flashes per km² per year [31]. The Planetary Radio Astronomy experiment (PRA) was also used, but results were inconclusive [32].

A lightning-like phenomena, later designated Saturn Electrostatic Discharge, was discovered at Saturn by Voyager 1 in the ring system. The signals received by the PRA varied with a period of 10 hours 11 minutes, indicating that the source lay in an orbit around Saturn at a distance of 1.8 Saturn radii. This placed the discharge origin in the centre of the B-ring, not in the atmosphere as in the case of Jupiter [33]. The Voyagers found no trace of any objects in the B-ring at that position, so resolution of the mystery must await a future Saturn orbiter mission [34].

The Galileo atmospheric probe should get closer exposure to Jovian lightning sometime at the end of this decade. Several lightning effects below the cloud tops will be scrutinised by the Lightning and Radio Emission/Energetic Particle Detector. In addition, the Orbiter will carry a special Canadian low-light "camera" to study lightning and aurorae optically [35].

Manned Observations

One of the most captivating sights seen from Earth orbit is displays of lightning on the darkened planet below. Astronauts and cosmonauts have often described spectacle during their flights, and recently a lightning experiment has been carried aboard the Space Shuttle.

During the sixth orbit of Vostok 6 in 1963, in group flight with Vostok 5, the two cosmonauts noted that lightning flashes made the clouds blink on and off as though someone were trying to signal [36]. John Glenn reported lightning over the Indian Ocean illuminating cloud interiors "as if they held bulbs which pulsed on and off" [37].

Lightning Research from Space/contd.

Lightning was even visible to lunar voyaging Apollo astronauts. Returning home from the Moon in November 1969, Apollo 12 commander Charles Conrad saw lightning on Earth from 30,000 km (away.) The flashes appearing to be "ripping up the entire nighttime side of the Earth" [38].

The crews of the American Skylab space station were particularly impressed by the natural light shows. Skylab 4 commander Gerald Carr described a large display in Africa, south of a series of bright brush fires. "There was an overcast with many thunderstorms, and many bright flashes of lightning going on at the same time . . ." [39]. Ed Gibson of Skylab 4 was awed by an apparent "collective organisation to the lightning strikes which occur over a wide area. When one goes off, two or three may go off simultaneously, or one of those may turn out to trigger a whole lot of other ones all over a very, very wide area – 500,000 square miles, perhaps . . ." [40].

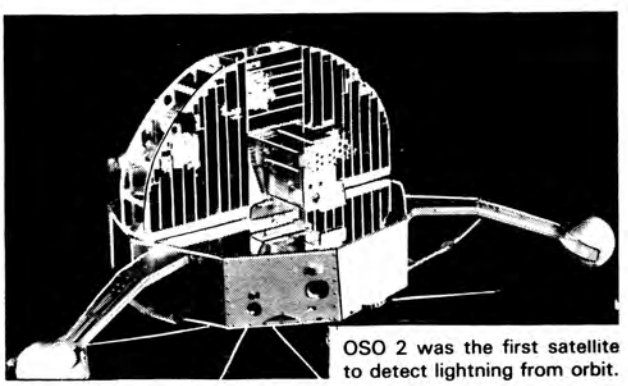
Taking advantage of the opportunity for repeated visits into orbit afforded by the Space Shuttle, Dr. Bernard Vonnegut of the State University of New York at Albany is now conducting an optical space lightning experiment. Designated NOSL (Night/Day Optical Survey of Lightning) the experiment was flown on STS 2, 4 and 6 [41].

NOSL is relatively simple, consisting of a 16mm window-mounted movie camera with a diffraction grating, a warning device and photocell, as well as a cassette tape recorder. During daylight passes lightning is filmed by an astronaut for electrical phenomena and storm dynamics studies. Nighttime runs use the diffraction grating to acquire spectrographic information revealing "temperature, pressure, molecular species, electron density and percentage of ionization data within a lightning path" [42].

Unfortunately, NOSL operations were cut short by the premature end of the STS 2 mission. Only one three minute exposure had been made (with lightning recorded on only four consecutive frames) out of four opportunities radioed up to the crew. The photocell also recorded one event. Arrangements were made to refly the experiment at the next available opportunity [43,44].

Results from STS 4 were more satisfying. On Day 2 the crew recorded the first of their lightning observations over Buenos Aires and Rio de Janiero [45]. Pilot Henry Hartsfield described one remarkable aspect, "We saw what would appear to be sympathetic lightning strikes where discharges would occur in a thunderstorm," similar to Ed Gibson's observations, "and then you would see a sequence of discharges working its way up a line that would be 400 to 600 miles long. It was unbelievable the extent to which it went" [46].

It is hoped that the experiment will be useful in learning to recognise tornado-producing storms by the pattern of their lightning, the circulation patterns that might be revealed by the light flashes, and the way in which reflected Sunlight is altered by such clouds. The data will be compared to lightning measurements made by the NASA U-2 aircraft [47].



OSO 2 was the first satellite to detect lightning from orbit.

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SATELLITE DIGEST – 164

Robert D. Christy
Continued from the May issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

COSMOS 1424 1982-117A, 13725

Launched: 1000, 16 Dec 1982 from Tyuratam by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical reentry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6 m, diameter (max) 2.4 m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered or re-entered after 43 days.
Orbit: 171X349 km, 89.70 min, 64.90 deg, manoeuvrable.

AMS 5 1982-118A, 13736

Launched: 0230, 21 Dec 1982 from Vandenberg AFB by Thor Burner 2.
Spacecraft data: Not available.
Mission: Military meteoroligical meteorological satellite.
Orbit: 815X828 km, 101.35 min, 98.72 deg.

COSMOS 1425 1982-119A, 13739

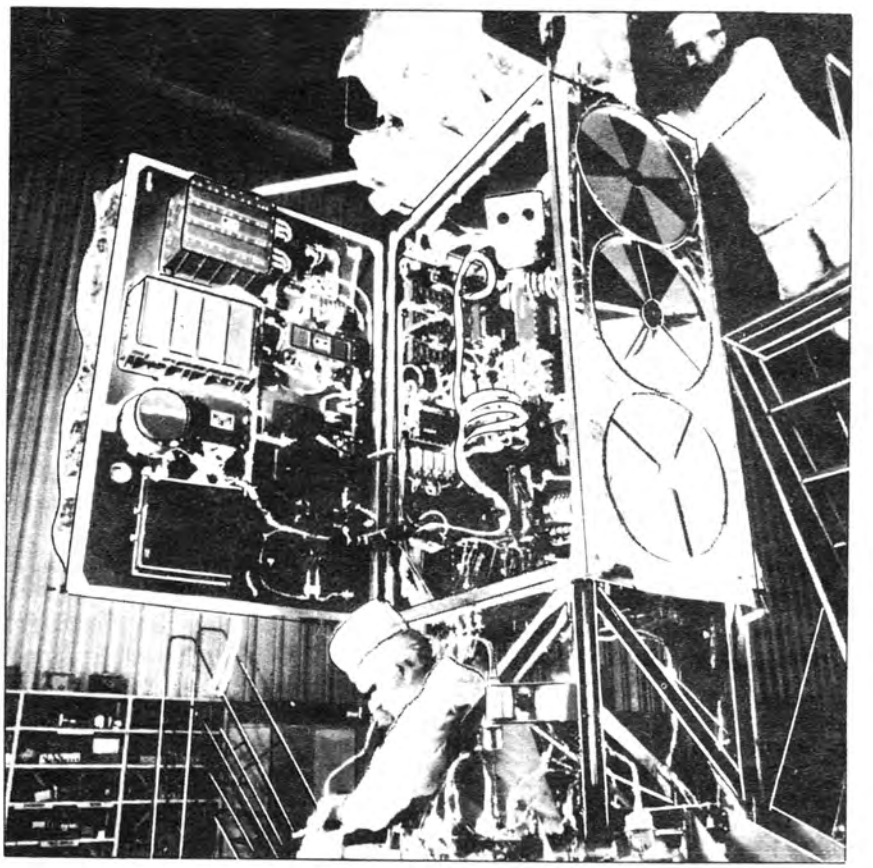
Launched: 0910, 23 Dec 1982 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1424.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 348X415 km, 92.20 min, 69.97 deg.

COSMOS 1426 1982-120A, 13745

Launched: 1200, 28 Dec 1982 from Tyuratam by A-2.
Spacecraft data: Possibly as Cosmos 1424, although the design may have been based on the Soyuz vehicle.
Mission: Photo-reconnaissance and possibly carrying out parallel studies with the unmanned Salyut 7.
Orbit: 205X351 km, 90.00 min, 50.53 deg, manoeuvrable.

COSMOS 1427 1982-121A, 13750

Launched: 1200, 29 Dec 1982 from Plesetsk by C-1.
Spacecraft data: Not available.
Mission: Possibly a radar calibration satellite.
Orbit: 445X500 km, 94.03 min, 65.84 deg.



A Tiros weather satellite, similar to the AMS military meteorological satellite launched on 21 December 1982, is assembled at RCA. The Tiros series might be cut back (see this month's "Space Report".)

RCA Astro-Electronics

COSMOS 1428 1983-1A, 13770

Launched: 1350, 12 Jan 1983 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in a cylindrical solar array with length and diameter both about 2 m, mass around 700 kg.
Mission: Navigation satellite.
Orbit: 955X1007 km, 104.74 min, 82.91 deg.

COSMOS 1429–1436 1983-2A-H, 13761-13768

Launched: 0220, 19 Jan 1983 from Plesetsk by C-1.
Spacecraft data: Probably spheriodal in shape; around 1 m long, 0.8 m diameter and mass approx 40 kg each.
Mission: To provide tactical communications between troops and units in the field.
Orbits: 1401X1468 km, 114.56 min, 74.02 deg (lowest), and 1468X1521 km, 115.87 min, 74.02 deg (highest).

COSMOS 1437 1983-3A, 13770

Launched: 1730, 20 Jan 1983 from Plesetsk by A-1.
Spacecraft data: Possibly based on the Meteor satellite body with a cylinder, length about 5 m, diameter about 1.5 m and mass around 2000 kg.
Orbit: 630X657 km, 97.60 min, 81.17 deg.

BOOK NOTICES

Comets
Ed L. L. Wilkening, University of Arizona Press, 766pp, 1982, $29.95.

Although comets have, for centuries, captured the imagination of mankind, the forthcoming probes to Halley's Comet have stimulated exciting new studies of these mysterious objects. There are now many more observations of faint and distant comets, new models of cometary activity and new data concerning the nature of cometary solids. Other stimuli have also been at work. For example, the long and successful operation of the International Ultraviolet Explorer satellite has made possible some crucial observations of H and OH in the extended comae of comets. Additionally, the collection

of interplanetary dust in the Earth's stratosphere has yielded new clues on the nature of cometary dust, while the Pioneer Venus Orbiter has provided a detailed picture of the interaction of the solar wind with an atmosphere unprotected by a magnetic field.

These new theories, and much new data, are collected in this volume to provide an introduction to comets for newcomers, as well as a reference volume for specialists.

Unfortuntely, data relating to comets are spread among a multitude of publications, mostly inaccessible to the general reader. For this reason alone, the appearance of a volume which collects in one place a distillation of current thought on these bodies is to be welcomed.

All told, this work contains 48 contributions, its main text being concentrated on the essence of cometary studies *viz* the nucleus, dust, the coma and the tail/solar wind interactions. Other contributions relate to the origin and evolution of comets, statistical information on past discoveries and a selection of useful references.

Observing Earth Satellites
D. King-Hele, Macmillan, 184pp, 1983, £9.95.

The author probably ranks first among those most qualified to write such a book in the UK, having made more than 8,000 visual observations of artificial satellites since 1957.

The number of satellites in space has grown at a spectacular rate. There are currently about 5000 orbiting the Earth, and the number continues to rise. About 200 of these are visible to the naked eye when conditions are right, and about 2000 can be seen with 7 × 50 binoculars. Watching satellites with binoculars and timing them by stopwatch as they pass known stars has become a valuable scientific endeavour because the orbits determined from these and other observations can be analysed to study the shape of the Earth and the behaviour of its upper atmosphere.

This volume is a practical guide for anyone who wants to find out more about this exciting feature of the night sky. It explains clearly how to make observations and provides all the details needed for the accurate plotting and recording of satellite sightings. More advanced techniques, such as radio observation and photography, are also described, together with laser tracking.

Besides these aspects, the book gives clear and simple accounts of a satellite's launch, orbital behaviour and final fiery descent. It provides a wealth of up-to-date information on satellites currently in orbit, from large structures down to tiny fragments stemming from orbital explosions.

Members will be particularly pleased to know that Dr. King-Hele lists the Society, with its address, in an appendix giving details of organizations able to provide further information.

The 1983 Satellite Directory
Phillips Publishing Inc., 49pp, 1982, $95.00.

This is the fourth annual compilation designed to meet the business needs of the US communications industry though it will also serve as a reference book for many in the satellite industry generally. The fact that this is a dynamic and expanding field is borne out by the inclusion of over 50 per cent more company entries than in the 1981 edition.

The volume contains descriptions of major US domestic commercial satellite systems, operational satellites and customers, together with information about international satellite systems, their satellites and member-countries. The directory also lists US Government agencies as well as Congressional committees and sub-committees concerned with satellites, plus those companies and associations which provide goods and services to the satellite industry. It lists all licensed Earth stations in the United States, presented in six different formats. There is also an extensive listing of satellite hardwear manufacturers and distributors and a list of Marisat terminals, now part of the Inmarsat system.

The 1769 Transit of Venus
B. Nunis, Jr., 185pp, Natural History Museum of Los Angeles 1982, $60.00.

Transits of Venus across the face of the Sun in 1761 and 1769, and again in 1874 and 1882, were of great importance to the international community of astronomers. These events had been anticipated since 1679, when Halley indicated their value in determining the solar parallax, leading to the mean distance between the Earth and Sun, and thus the scale of the Solar System. Computation methods required different sets of observations of each transit from widely separated points of the globe, so scientists of many nationalities made observations in both centuries, stationing themselves in remote places and enduring great hardships in their efforts.

In 1769 the French astronomer Chappe, and the two Spanish astronomers Vicente de Doz and Salvador de Medina journeyed together from Europe to Baja California to observe the transit. The peninsula was also the observation place of Mexican-born Joaquín Velázquez Cárdenas de León, a self-taught astronomer. These men were the first scientists to collect and record data on the California coast. The accounts of their observations are brought together for the first time in this new book.

An extensive introduction contains biographical information on the men, an account of their adventures in the New World and a description of the scientific and political context in which they worked. In addition to documenting individual courage and perseverance, the book gives a vivid impression of early scientific methods.

Some of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

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SPACEFLIGHT

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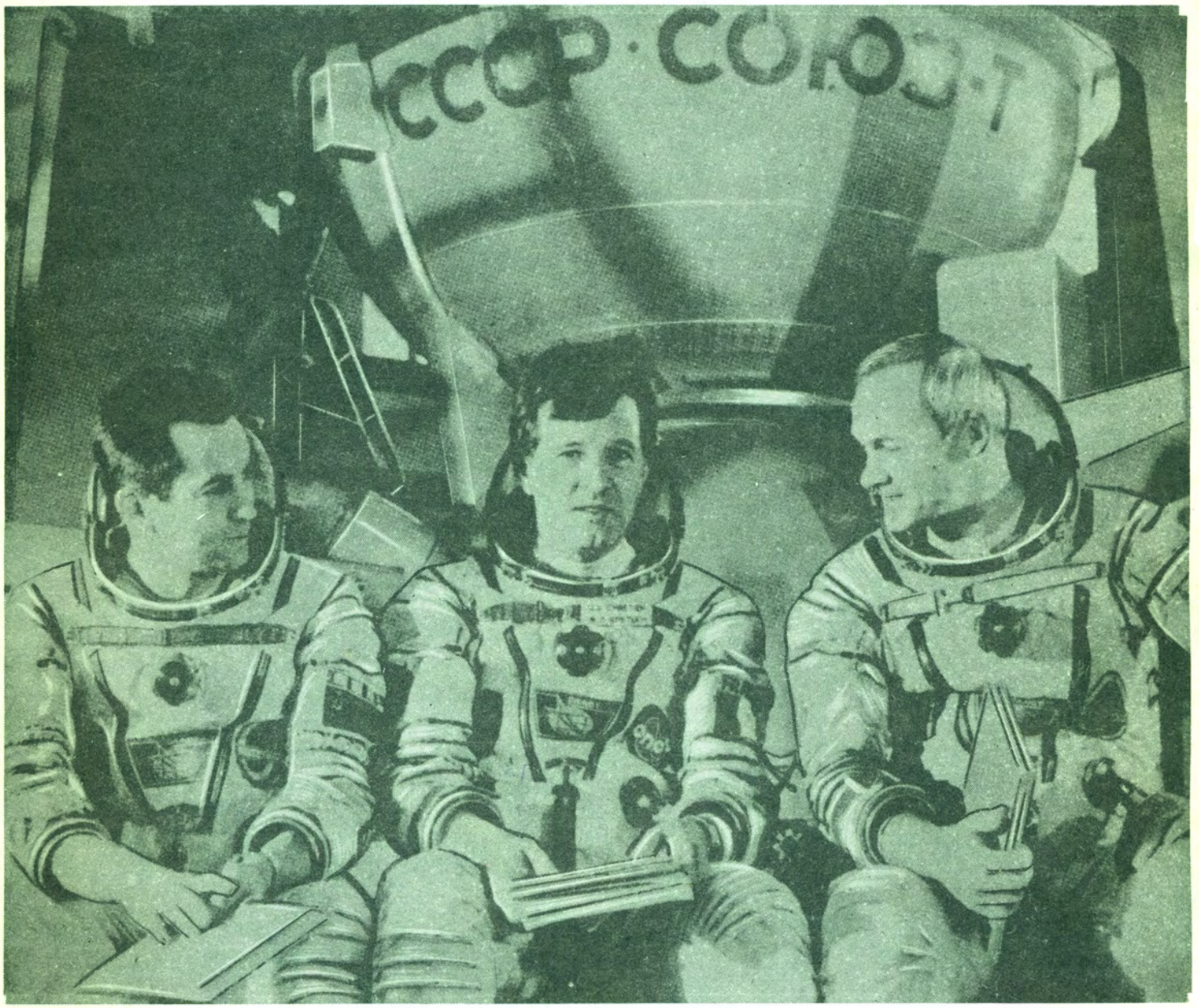

OUR 50th ANNIVERSARY YEAR

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JULY/AUGUST 1983
VOLUME 25 Nos. 7 & 8

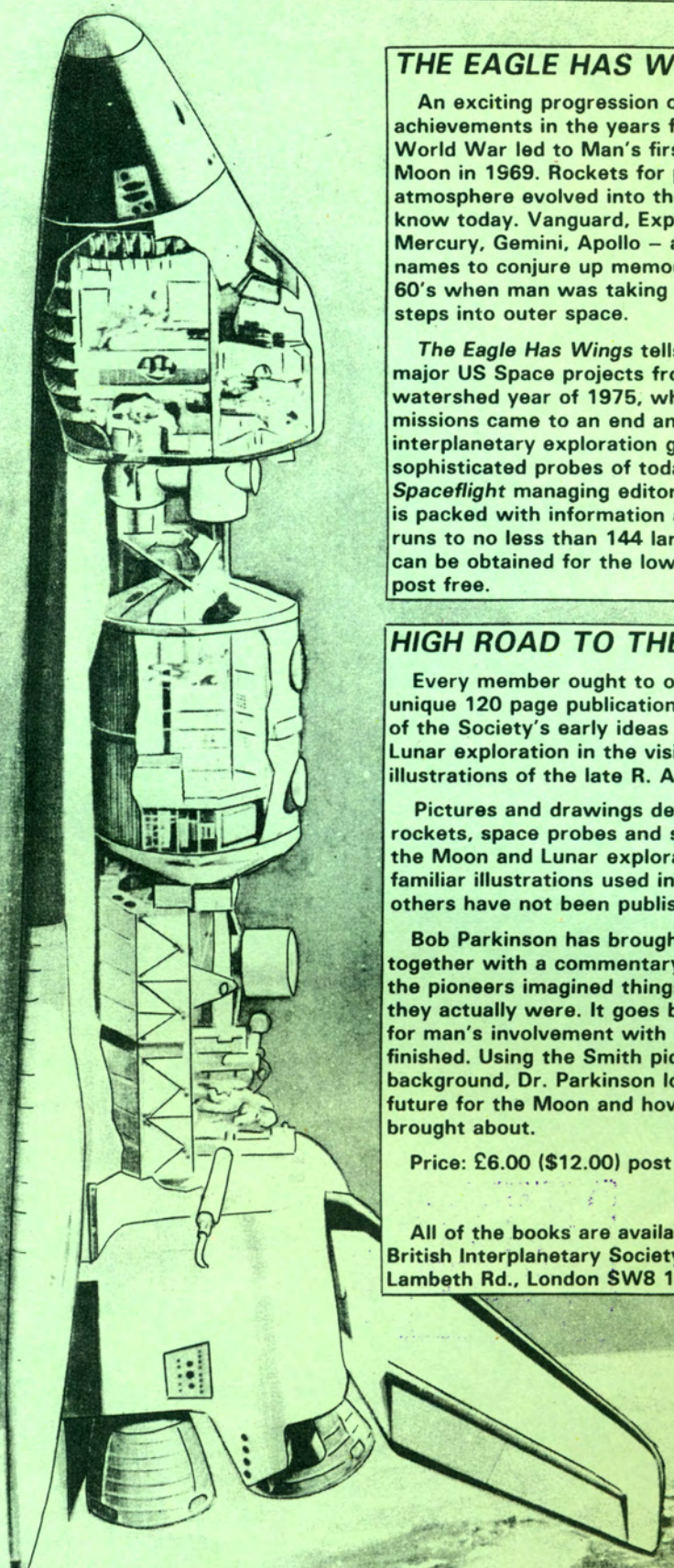
SOCIETY BOOKS

PROJECT DAEDALUS

The publication of the Project Daedalus Final Report marked the end of years of painstaking work by a group of BIS pioneers. The BIS received congratulations from around the world for its far-sighted project: designing a probe for man's first crossing of interstellar space.

The Final Report Report contains 24 papers spread over 192 large-format (A4) pages, summarising the four year study. The papers cover the overall spacecraft design, mission profile, computer systems, navigation, experiments and our knowledge of nearby stellar systems, some of them possibly with planets.

"Daedalus" is acknowledged as a milestone in the the development of advanced astronautics. Copies of the Report cost just £7.00 ($14.00) post free.



THE EAGLE HAS WINGS

An exciting progression of space achievements in the years following the Second World War led to Man's first landing on the Moon in 1969. Rockets for probing the upper atmosphere evolved into the space launchers we know today. Vanguard, Explorer, Atlas, Titan, Mercury, Gemini, Apollo – a succession of names to conjure up memories of the 50's and 60's when man was taking his first tentative steps into outer space.

The Eagle Has Wings tells the story of the major US Space projects from 1945 to the watershed year of 1975, when the Apollo missions came to an end and the first wave of interplanetary exploration gave way to the more sophisticated probes of today. Written by *Spaceflight* managing editor Andrew Wilson, it is packed with information and photographs. It runs to no less than 144 large-format pages and can be obtained for the low price of £7 ($14.00) post free.

HIGH ROAD TO THE MOON

Every member ought to own a copy of this unique 120 page publication which records many of the Society's early ideas and discussions on Lunar exploration in the visionary drawings and illustrations of the late R. A. Smith.

Pictures and drawings detail plans for orbital rockets, space probes and ships to take men to the Moon and Lunar exploration. Some are familiar illustrations used in books of the time: others have not been published before.

Bob Parkinson has brought these pictures together with a commentary which tells how the pioneers imagined things would be and how they actually were. It goes beyond the present, for man's involvement with the Moon is not yet finished. Using the Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.

Price: £6.00 ($12.00) post free.

All of the books are available from: The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ, England

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CONTENTS

290 **Spacelab Crew Prepares for Launch**
John Bird

292 **Countdown for *Columbia***

294 **Correspondence**

297 **IRAS Discovers Comet**

298 **Society News**

300 **What's New in the Library**

303 **Towards the Stars**

304 **Lunar & Planetary Conference**
James D. Burke

306 **Meteorites from Mars?**
Staff of NASA

308 **Space at JPL**
Dr. W. I. McLaughlin

312 **Test Your Space Knowledge**

314 **Space Communications**

315 **Space Report**

319 **Japan's New Rocket Engine**
Neil W. Davis

321 **The 1950's – A Pivotal Decade**
Adrian Perkins

326 **MOS-1: A Japanese Landsat**
Dr. J. K. Davies

328 **Personal Profile**
F. I. Ordway

332 **The Neil Armstrong Air & Space Museum**
Keith T. Wilson

334 **Satellite Digest – 165**
Robert D. Christy

335 **Milestones**

336 **Book Notices**

SPACEFLIGHT

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A GOOD DEAL FOR MEMBERS

The success of our Space '82 meeting last November prompted many members to ask, "When will the next be?" Now we can respond with: Space '84 will be held on 16–18 November 1984 in Brighton, again with a host of experts and personalities from the space field. Experience shows that members who want to come ought to book as early as possible to avoid disappointment; the numbers have to be held down if we are to keep that friendly atmosphere which seems to vanish in larger gatherings.

Space '84 provides a good lead-in to our future meetings programme. Many members prefer to come to the larger, more significant events, even if held less frequently because of the extensive workload they require.

One-day meetings such as those on Daedalus and Soviet space activities are good examples of the type of meetings which members like. Such meetings are not only useful in their own right but they also provide a spin-off in terms of papers for publication and media publicity. So the next in this series will be a one-day meeting on Planetary Exploration on 5 October (see back cover for details).

We find that filmshows are still very popular with members, so we will continue these as before.

On financial matters, UK members will be delighted to know that, in spite of higher costs, the Council has decided to keep the 1984 membership fees at the 1983 level. Overseas members who pay in dollars will be even happier to find a significant decrease in the amounts they pay, caused by the improvement in their exchange rates.

This October will see the Society reach its 50th Anniversary – half a century of promoting space travel for the benefit of mankind. To mark the event, we are holding a celebration dinner at Society headquarters during the evening of Friday, 21 October 1983 for members and Guests of Honour.

The celebration is open to members, who may introduce one guest each. The cost is £15 per person, which covers an apperatif, a 4-course dinner and wine.

Why not join us to mark a significant event in the Society's history? Places are restricted so early application is essential.

COVER

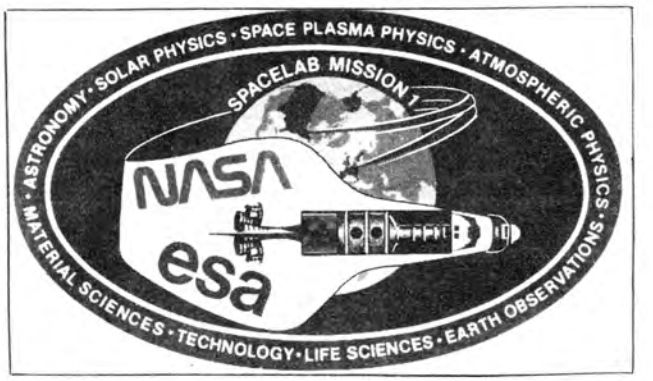
The Society's Guest of Honour at the 18th European Space Symposium at headquarters on 8–9 June is French cosmonaut Jean-Loup Chrétien (pictured on the cover between his two Soviet cosmonaut colleagues), who will describe his Soyuz/Salyut mission.

Novosti Press Agency

SPACELAB CREW PREPARES FOR LAUNCH

By John Bird

After three years of planning, the final preparations are underway for the autumn launch of the joint NASA/ESA Spacelab 1 mission. Author John Bird, after thrilling us with his astronaut training sessions below water and above the Earth in the February and April issues, now provides a brief insight into what the Spacelab astronauts are doing.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The Spacelab 1 mission badge, showing the points of origin of the Shuttle (USA) and Spacelab (Europe). The border names the areas of scientific investigation on the flight.

Introduction

Performing more than 70 scientific investigations to demonstrate Shuttle/Spacelab capabilities was described as the key Spacelab 1 objective in a discussion I had with mission manager Harry Craft. We were monitoring communications between the crew members and the ground support team during a recent simulation at Marshall Space Flight Center in Alabama.

"CIC this is Spacelab." reported Ulf Merbold, the first foreigner selected to fly on a US space mission.

"Go ahead" was the reply from the Crew Interface Controller, who sat in front of me. We were in the Payload Operations Control Center, or POCC, where a dozen people monitored simulated telemetry on control consoles, watching the crew on closed circuit TV as they prepared to install an experiment in the overhead airlock. Others in the POCC included the Payload Operations Director and the Payload Activity Planner, who helps to devise on-the-spot changes in the flight plan as required.

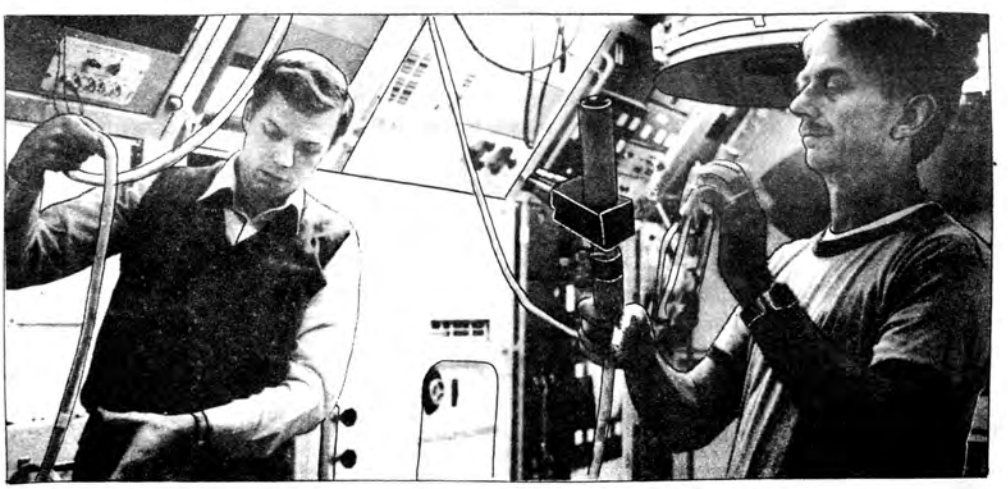
The POCC was located in a building beside the Payload Crew Training Center where the simulator was housed. During the actual flight, it will be found in the Johnson Space Center in Houston. The POCC also provided the communications link between Spacelab and the various experiment groups that had representatives in rooms adjacent to the main control room. This allowed the scientists to monitor the results as they came down.

"Is the shutter closed yet?" asked Dr. Merbold.

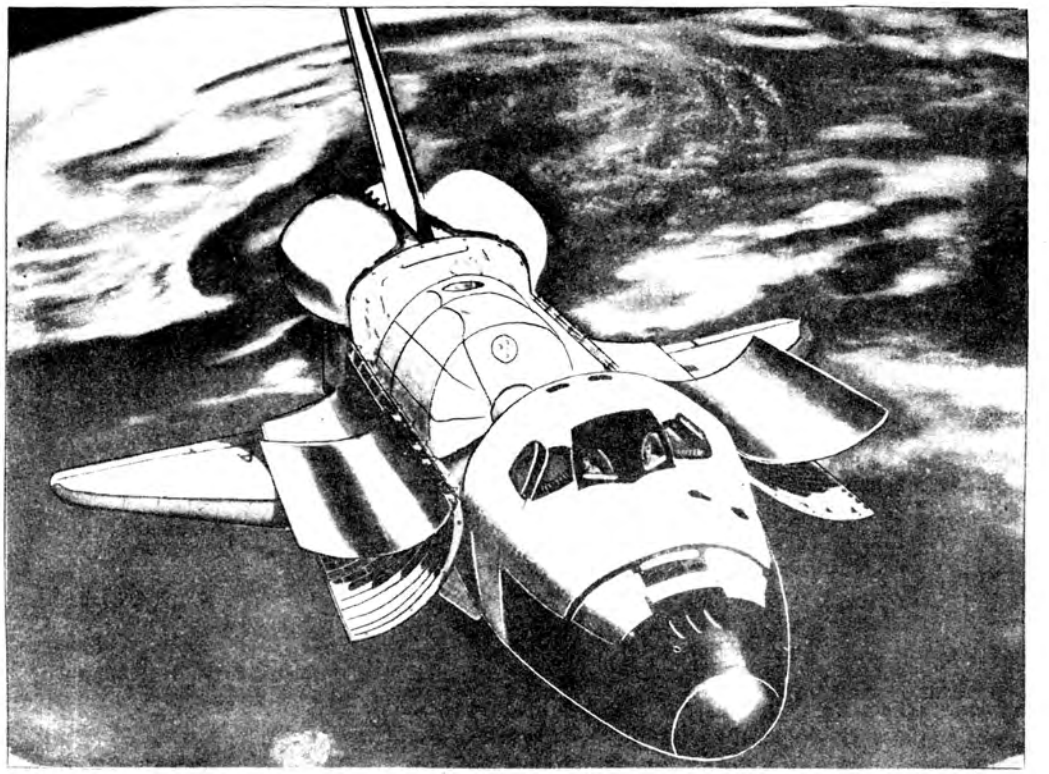
"Not on my display" was the reply from the ground crew as they threw in a simulated malfunction.

"Say again, I can hardly read you" was the reply from the ground as a communications problem was also added. The purpose of this simulation was to allow the operations people, flight crew scientists, and investigators to see how well their planned schedules, crew procedures, computer programs, and display formats stood up. During the simulation, as in the flight, two of the four science crew members worked 12 hour shifts in the module while the other two were off duty.

The simulations will occur every few weeks up to the launch while the flight hardware undergoes integration with the Shuttle *Columbia* at the Kennedy Space Center. The flight configuration consists of a pressurized module where the scientists will work, an outside pallet on which some of the experimental hardware is mounted, and a tunnel connecting the Orbiter cabin with the Spacelab module. All of the hardware will stay in the cargo bay throughout the seven day flight.



Owen Garriott (mission specialist, right) and Byron Lichtenberg (payload specialist) at work in the Spacelab simulator. More pictures in the following feature.



Columbia as she will appear in orbit with the Spacelab modules in the open cargo bay.

The Flight

The Spacelab 1 experiments cover astronomy, atmospheric physics, life sciences and materials science. As part of the general design philosophy for reduced costs and quick turnaround, some of the hardware is designed to be reflown. An example is the Imaging Spectrometric Observatory. It consists of five nearly-identical spectrometers each designed to look at a different wavelength band, or colour. It will be used to investigate airglow and auroral phenomena in the Earth's atmosphere.

SEPAC (Space Experiments with Particle Accelerators) is a Japanese experiment which will eject electron beams and neutral gas clouds from the pallet; the resulting light emissions will be observed by TV cameras.

In the life sciences area, some of the experiments will investigate the physiological problems associated with weightlessness. These problems include motion sickness which has been experienced by many astronauts during the first few days of space flight. To help pin down the cause, ESA has designed an experiment to investigate the interaction of the vestibular system of the inner ear (which provides balance) to visual stimulation. A crewman will wear a helmet which records motion of one eye while providing images to the other. Another crew member will move the wearer in zero g to provide translational and rotational accelerations.

Materials science experiments will investigate crystal growth, fluid physics and metallurgy. Astronomy experiments include ultraviolet studies and solar physics.

The crew for this flight is the largest ever. There will be a total of six: the commander, pilot, two mission specialists (NASA scientist astronauts), and two payload specialists (scientists). The commander is John Young who flew Geminis 3 and 10, Apollos 10 and 16, and STS-1, the first Shuttle mission. Also flying the Shuttle will be rookie astronaut Maj. Brewster Shaw. The mission specialists are Dr. Owen Garriott, who flew in Skylab, and Dr. Robert Parker. The payload specialists are Dr. Byron Lichtenberg, a biomedical engineer, and Dr. Ulf Merbold, a physicist from West Germany.

After the test I went into the Spacelab 1 simulator to view this electronically operational duplicate of the flight version. I was briefed on the location of electrical supply distribution boxes, emergency oxygen gear, stowage areas, experiment racks and airlock operation. The basic impression I had was that it was more like an airplane than a space station, but of course it is both. My impression was influenced by the numerous examples of hardware often seen in aircraft such as the "remove-before-flight" tags, and green anodized aluminium, as well as the general shape and size of the module.

During the flight there will be 24 hour a day coverage of the mission, including live transmissions from orbit, interviews with the investigators, and commentary from Houston. It will be the greatest show above the Earth, so don't miss it!

Beginning overpage is a two-page report on the work being carried out on Orbiter Columbia *to prepare her for the Spacelab mission.*

COUNTDOWN FOR *COLUMBIA*

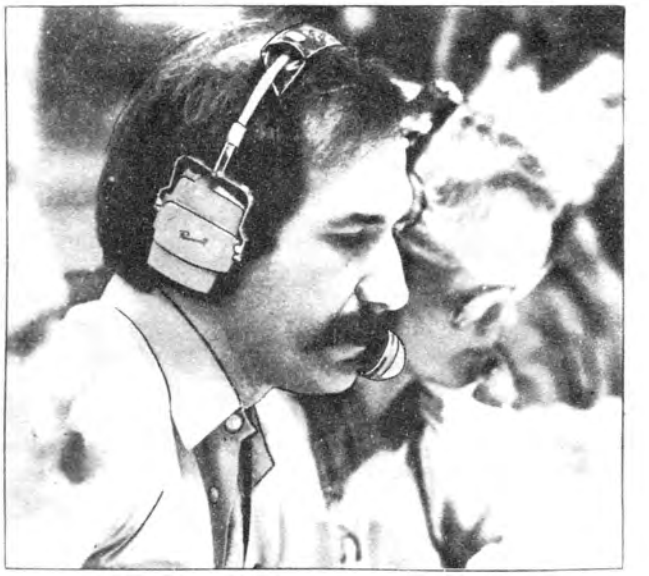
While Shuttle Orbiter *Challenger* has been grabbing the headlines, the first orbital ship, *Columbia*, has been quietly undergoing modifications to convert it from a flying test bed and prepare it for the important Spacelab mission this autumn.

Columbia is being modified at the Kennedy Space Center in Bay 2 of the Orbiter Processing Facility. In general terms, the changes will enable *Columbia* to carry Spacelab and accommodate the six-man crew. Other systems have been upgraded for added reliability and extended lifetimes.

An airlock and tunnel adapter so that astronauts and payload scientists can go back and forth between the *Columbia* and the Spacelab has been added. Oxygen lines will be routed from *Columbia* to the workshop where it will be mixed with the Spacelab's own nitrogen system to provide a breathable atmosphere.

Columbia's fifth flight (STS-5 in November 1982) carried the first four-man crew. The pilots' ejection seats, which have not been removed, limit the amount of room up on the flight deck so two more seats have been installed down on the mid-deck. They are of the same type of airliner-type chairs used on STS-5 for passengers, and are standard equipment on *Columbia*'s sister ship, *Challenger*.

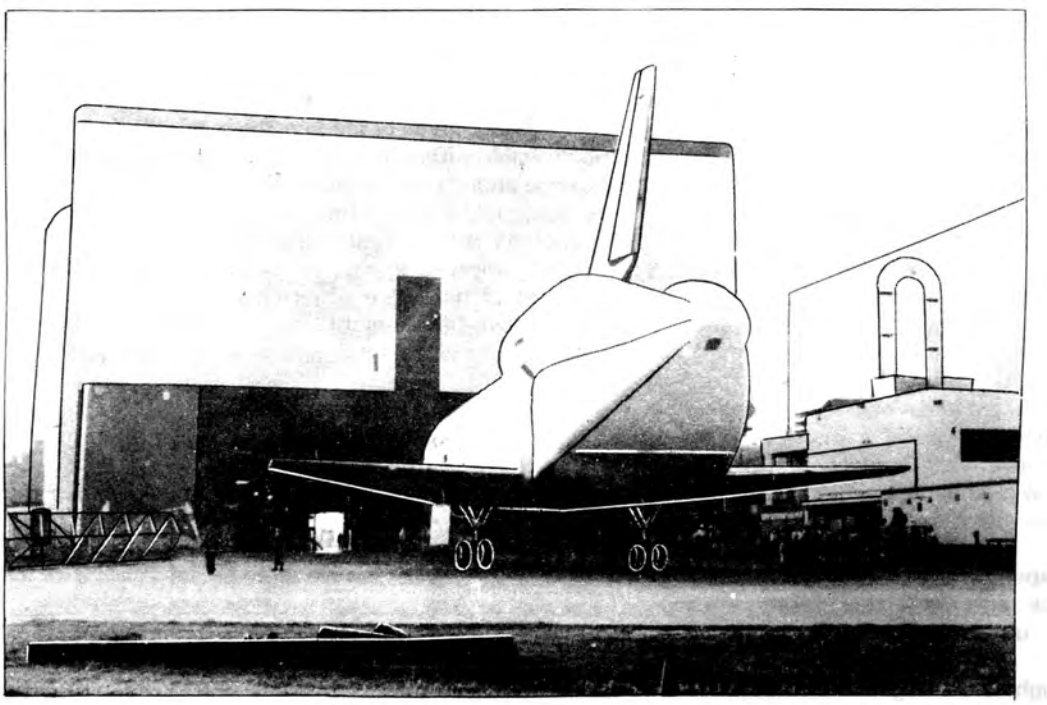
Since there are more people on board, a number of the modifications are to provide the crew with the comforts of home. A kitchen was installed in the mid-deck to serve as an eating and food storage area. A large rack of "development flight instrumentation" was removed to make room for the modern space kitchen. A "personal hygiene station" was also added in the area.



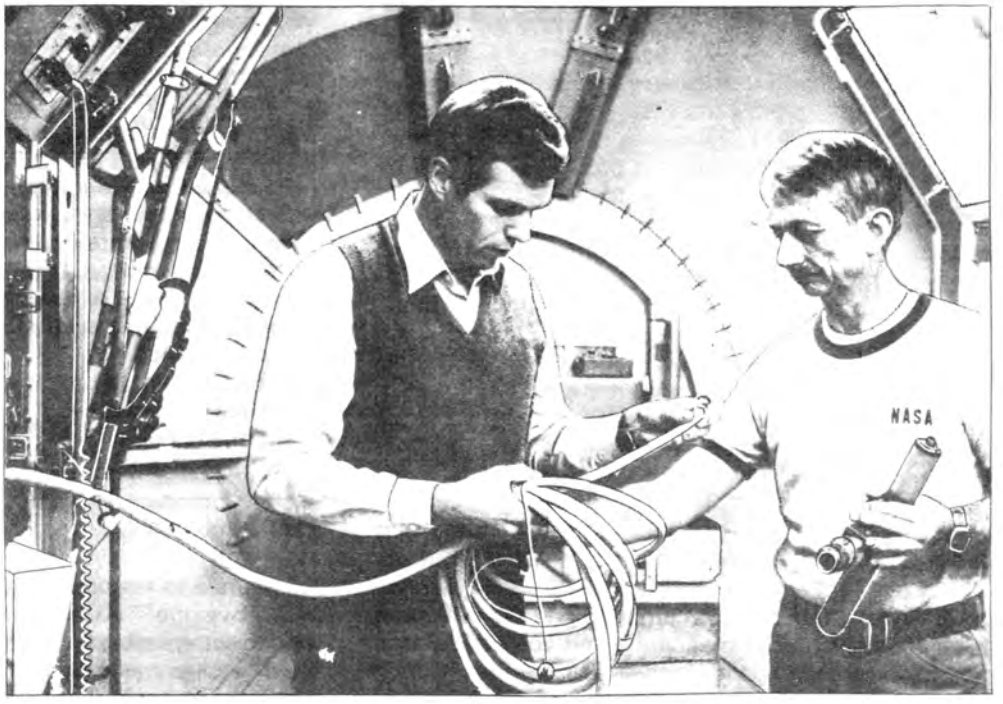
Wubbo Ockels, Europe's Spacelab 1 payload specialist, takes part in a *Columbia* Spacelab training exercise.

Since the crew will work and sleep in 12-hour shifts, three bunk beds were installed on the other side of the mid-deck with sleeping bag restraints. Three hammock-type sleeping bags were also included.

More people means more equipment, so additional permanent lockers and compartments were added, many of them under the mid-deck floor. Changes were made to provide adequate breathing air for the larger crew and portable oxygen systems were installed for the added crewmen.



Columbia was towed into the Orbiter Processing Facility last November to begin modifications.



Owen Garriott, Spacelab 1 mission specialist (right), and Byron Lichtenberg, payload specialist, confer inside the space laboratory.

NASA

To handle the additional Spacelab power requirements and to provide an abundant supply of liquid reactants which can be converted into breathing air for the crew, several major changes were made to the power reactant storage and distribution (PRSD) system.

The three standard two sub-stack fuel cells, which provide electrical power, were replaced with fuel cells that have three sub-stacks, thus increasing the available voltage margin. The number of cryogenic storage tanks, which hold and supply the super cold reactants to the fuel cells, is being increased from three to five sets. All five of the oxygen tanks are new, designed for added durability and reliability over the 100-mission lifetime of *Columbia*.

Some of the other modifications include: a new set of stronger main landing gear wheels, plus a modified set of brakes; between 400 to 600 payload bay insulation blankets were replaced with blankets made of a stronger, more heat resistant material and the heat-rejecting radiators inside the cargo doors were replaced with new diffuse coated radiators for reduced glare and better heat-rejecting capability.

Other items include some 100 electronic "black boxes," the reinforced carbon-carbon panels on the leading edge of the two wings and several antennae. The carbon-carbon panels are going back to their manufacturer for treatment to increase their resistance to oxidation and increase their mission life.

Many of the "black box" changes are to upgrade *Columbia*'s instrumentation systems and because of the removal of the development flight instrumentation. Substantial rewiring added about 100 more measurements previously undertaken by the development instrumentation to the Orbiter's Operational Instrumentation System.

A text and graphics unit was added to allow black and white facsimiles to be sent to the Orbiter from the ground. The unit will also receive digital data from the Ku-band signal processor and supply the crew with a hard copy of the processed data.

Three of *Columbia*'s tactical air navigation (TACAN) units, used as an external navigation aid during reentry, were replaced with upgraded units, and the four quadrant S-band antennae were replaced with new antennae to communicate with the Tracking and Data Relay Satellite.

The S-band system, which has a larger beam width compared to the narrow pencil beam of the Ku-band system, will be used to lock on to the Tracking and Data Relay Satellite. Once the S-band signal is acquired, the Ku-band signal can be turned on.

A new Ku-band antenna will be used specifically for transmitting Spacelab information down to the ground *via* the TDRS satellites.

Columbia's engine subsystems also received a thorough going-over. The twin Orbital Maneuvering System pods and the forward Reaction Control System were removed and processed in the Hypergolic Maintenance Facility. The three main engines are being overhauled for use on the fourth Orbiter, *Atlantis*. These engines, which operated at 100 per cent of rated thrust on *Columbia*, will be modified and retested to certify them for operation at 109 per cent aboard *Atlantis*. *Columbia* has a brand new set of main engines and additional leak detection development was added in the engine compartment.

While in the Orbiter Processing Facility technicians removed and densified more of the thermal tiles that have not previously undergone the strengthening process. About 2,400 tiles, all on the belly area, were treated.

Spacelab will be installed in early August and tests conducted to verify proper operation of the integrated vehicle. *Columbia* is scheduled for a late August to early September move to the Vehicle Assembly Building for mating with its boosters and External Tank.

CORRESPONDENCE

Forecast of Manned Progress in Space

Sir, Regarding the table forecasting man's future space activities, in the June issue (see right), it was Arthur Clarke, I believe, who said that prophecy tends to be too optimistic in the short run, too pessimistic in the long run. My first reaction is that the table is too pessimistic both in the short run (there are a lot of people in the Aerospace industry who are hoping that the Permanent Manned Space Station will be in business before 1990), and in the long run (no real manned exploration of the Solar System for another century!).

More seriously, what is required is not so much a list of when we should be doing things in space, but an identification of the critical items which control our activities. At the moment transport cost into low Earth orbit is one such – and one way or another the existence of a US Manned Space Station will depend on that factor. Drop it by an order of magnitude (from $2000/kg to $200/kg) and we would not only have a US Space Station but a European one as well. Drop it by another order of magnitude and you have Space Tourism – people spending their holidays on "Orbital Hilton's". The first step could be achieved just by investment, technology for the second step could be available by the end of the century.

Similarly, a really economic inter-orbital propulsion system (ion, gas-core nuclear or fusion) would not only make Lunar Colonies and Mars Colonies simply a matter of whether we wanted to afford them, but make voyages to Jupiter and Saturn incidental. Our activities in space are not yet massive enough to require them, but I refuse to believe that we shall have to wait until the middle of the next century.

On the other hand, there are things that could make it all unnecessary. How long do you think it will be before machine intelligence is capable of running high level autonomous operations in Space? Does the first intelligent robot on the surface of – say – Venus count as a "manned landing"?

R. C. PARKINSON
Aylesbury

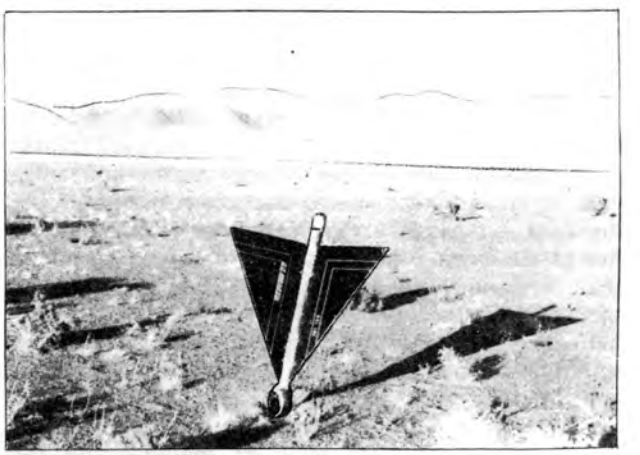
The prediction of Man's progress in space from p.251 of the June issue:

Permanent space station	1990 (1991)
First geostationary mission	1995 (1998)
Permanent geostationary station	2000 (2001)
Return to lunar orbit	2007 (2009)
Return to Moon's surface	2010 (2012)
Permanent lunar orbit station	2008 (2010)
Mars landing	2010 (2015)
Permanent lunar base	2016 (2020)
Permanent Mars base	2050 (2060)
Flight to Jupiter	2100 (2120)
Flight to Saturn	2120 (2140)

Goddard's Centenary

Sir, With reference to the article "Celebrating Goddard's Centenary" in the April issue, I would like to add a note on the Rocket Research Institute's contribution to the celebrations with a mail-carrying rocket.

The cargo rocket used was the spare from our 1957 IGY flight which the Jack Knight Society (he was an airmail pioneer pilot) had purchased from us in 1957 when it was no longer required. Some of our staff advisors from the midwest donated the funds to have the rocket shipped to California for refurbishing. On Saturday, 2 October, I flew from the IAF Congress in Paris to Washington; picked up the items that had been completed during the IAF Congress; and on Sunday morning, the 3rd, flew to Sacramento. Modifications were completed on the rocket by the morning of the 5th (it was quite a sensation, almost like an adventure in a time machine to see the rocket I designed 25 years ago restored to perfect flight condition) and we drove the 150 miles to our launch site for the Apollo commemorative flights near Reno, Nevada. After the launcher was assembled and the rocket prepared for flight, I took the photo of Bill Oliver with this 12 ft-long rocket; we cleared the area; and the crew launched the "Jack Knight" to honour the Centenary of Robert H. Goddard! The flight was perfect – the



body upon impact absorbed all the shock and the mail protected within the reinforced fins was completely undamaged. Bill Oliver's design for the reinforcement completely eliminated the crushed fins and mail we experienced with fins of this type in 1957. A heavy chain and four wheel drive truck had to be used to pull the rocket from the ground. By the time the mail was cancelled at the Reno Post Office and the crew had returned to Sacramento, it was 5.30 a.m. on the 6th. However, in spite of our exhaustion, there was a great sense of accomplishment; Dr. Goddard had been honoured in a manner he would have appreciated – as Mrs. Goddard had told me after we travelled over 1,200 miles to Roswell, New Mexico, in 1964 to help her dedicate the US Goddard stamp with the launching of two mail rockets.

GEORGE S. JAMES
Rocket Research Institute,
California, USA

Space Stations

Sir, I noted with interest Roger Wheeler's letter in the February issue and A. Non's letter in the November 1982 issue where they refer to the space station mock-up at the Ideal Home Exhibition, London in 1960.

I have some details to offer. As I understand it, the London *Daily Mail* commissioned the design and entered into a contract with the Douglas Aircraft Company of Santa Monica in California for a prototype design. I gather from A. Non's letter that Bristol-Siddeley provided the wherewithal to execute the project at the Exhibition.

The final Douglas Company report presenting the results of their study was SM 36173, prepared by W. Nissim and issued in November 1959.

ROBERT F. FREITAG
Deputy Director,
Space Station Task Force, NASA

Soviet Shuttle Test

Sir, The recent flight of Kosmos 1445 from the Kapustin Yar Cosmodrome on 15 March has again raised the question of Soviet tests of a winged scale model shuttle.

It would now appear that the Royal Australian Air Force has produced an answer. A few days before the craft spashed down in the Indian Ocean, 500 km south of the Cocos Islands, a maritime patrol sighted a fleet of seven Soviet naval vessels in the area. The task force was reported to consist of three space recovery vessels, a support ship, a space tracking ship, a Kara-class guided missile cruiser and a Kashin-class guided missile destroyer.

After the sighting a constant watch was placed on the fleet and on 16 March an Orion maritime patrol plane obtained pictures of the recovery of a winged vehicle from the ocean.

A Soviet helicopter moves in to recover the Kosmos 1445 reentry craft (arrowed). A further picture is included in this month's "Space Report."

From the pictures released by the RAAF the vehicle can be seen as being similar to the US X-23 vehicle, which conducted re-entry tests in December 1966 and March and April 1967. The major differences appear to be the addition of a central tail fin and a large cone near the nose of the vehicle which may have been part of the recovery system.

NEIL BLAND
Victoria, Australia

See this month's 'Space Report' for a picture of Kosmos 1445—Ed.

A Personal Note

Sir, Mitch Sharpe's "Personal Profile" (April *Spaceflight*) brought back memories of the witch at the party he mentions. By all accounts, she was having a high old time being invited to every party in the Deep South on the strength of being a real honest-to-goodness British witch. I remember her daughter tagged along in the aftermath as well. As a special treat, some of us were allowed to ask her to prophesise. She wasn't much good at that either.

More interesting was an astronaut who'd mentally left Earth some time previously. He was on a different plane from the rest of us. He appeared to be embalmed, with a gentle smile fixed on his face. The multitude who went up to him to pass comment, ask questions or merely to ascertain if he was real, were all greeted with that smile. It was a multi-purpose kit if ever I saw one.

The Manned Flight Awareness meetings to which Mitch refers were absolutely invaluable, as was his part in it. I remember the matter being raised with Dr. von

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

Braun on top of a Saturn V gantry. Looking down, one could well see the damage, not to say danger, should a hammer or some other heavy object fall. The question received the crisp response "Hammers do *not* fall!" There was manned flight awareness with a vengeance.

There was a particular event in the MFA programme that all BIS members will regard with pride. The venue at Cocoa Beach was crowded with distinguished figures who had contributed so much to the success of the Apollo programme, and who had gathered to hear a keynote Address by Arnold Frutkin, then NASA Associate Administrator for International Affairs. Arnold's remarks were well worth hearing but, catching sight of BIS representatives in the audience, he altered his words to make a special acknowledgement to the pioneering work undertaken by our Society.

It was so gracious and, in such company, one of the greatest compliments to the Society that I have ever heard.

L. J. CARTER
BIS

Mitch Sharpe replies:

I remember the Apollo launch when Len Carter, a couple of others and myself attempted to drive *behind* Pad 39. We were stopped by a security guard. At first my NASA badge was to no avail but we finally got things sorted out and he let us through. He also explained why he had only one shoe on: just before we arrived, he had gone out into the middle of the road to kick a young alligator off it. The gator grabbed the toe of his shoe and took it with him as he sailed into the ditch. Also, as I recall, on the same occasion, you all used more film on pictures of armadilloes than the magnificent Saturn 5 poised for its flight to the Moon.

I'm not sure if you ever saw Casey, the 12 ft long bull alligator that lived in the ornamental pond in front of KSC Headquarters. He came out at noon each day, unbidden, to beg lunch scraps from employees dining *al fresco* by the pond.

Shuttle Upper Stage

Sir, With reference to the article on "Satellite Handling for the Shuttle" in April's *Spaceflight*. There are two types of sunshield used on the McDonnell Douglas PAM-D and PAM-D2 systems. The standard sunshield, as used on STS-5 and visible in the photograph on p. 161, and the larger "growth" sunshield as depicted in the drawing on p. 162. The picture of the Shuttle in the background on p. 162 shows cradles without sunshields at all, a configuration which will never be seen in reality because the shields are an integral part of all PAM systems.

The choice of whether payload integration is performed horizontally in the Orbiter Processing Facility (OPF) rather than in the Vertical Processing Facility (VPF) is dictated by several factors. First, use of the OPF is usually more expensive than the VPF. Secondly, pre-launch customer access to the payload for checkout and maintainance operations is relatively straightforward if the VPF is used, but considerably restricted in the OPF. Also, the VPF route allows a shorter launch campaign by allowing processing to take place in parallel, rather than in series.

Spacelab is processed horizontally, in the OPF, and is often quoted as an example, whereas it is rather the odd one out. Vertical processing is the norm.

CHARLES RADLEY
Launch vehicle interface engineer,
British Aerospace

End of an Era

Sir, I was saddened to learn, in your February issue, of the deaths of two old friends. Ernest Dove was a long-time colleague of Val Cleaver, and I hope that fuller details may be given of his work on the early British rocket programmes.

Leslie Johnson, the first secretary of the BIS (in its pioneering Liverpool days) was very kind to me in the 1930's, patiently answering innumerable schoolboy questions. A few years ago he wrote his memoirs, and sent me a typescript which is now of considerable historic value.

While regretting their passing, I am happy to know that both Ernest Dove and Leslie Johnson saw their early dreams realised beyond even their wildest expectations.

ARTHUR C. CLARKE
Sri Lanka

SNIPPET

Cosmonaut Solovyov

Sir, in Part 13 of the Salyut Mission Report (*Spaceflight*, March, 1983) I wrote that the Soviet cosmonaut Vladimir Solvyov was selected as a cosmonaut in 1978. A new Soviet book, *SSSR – Frantsiya na Kosmicheskikh Orbitakh* by Rebrov, Kozyriev and Denisenko (*Mashinostroenie* Publishers, 1982) states that Solovyov was selected in 1977.

NEVILLE KIDGER
W. Yorks

WE ARE SEEKING RARE BOOKS ON ASTRONOMY, SPACE AND EVEN 19th CENTURY SCIENCE FICTION

The Society's Library is becoming a valuable asset – one of which members can be justifiably proud. We are grateful to all those members who have responded so magnificently in donating volumes to us and in helping us to track down works to plug the gaps in our collection.

With so much preliminary work done, the Society is now anxious to acquire books, documents or artifacts of a personal, and thus rarer, nature which it can preserve for posterity.

We need all the help we can secure if we are to develop a unique Society Archive collection for the benefit of future generations. If you feel you can help in any way, please contact the Executive Secretary.

IRAS DISCOVERS COMET

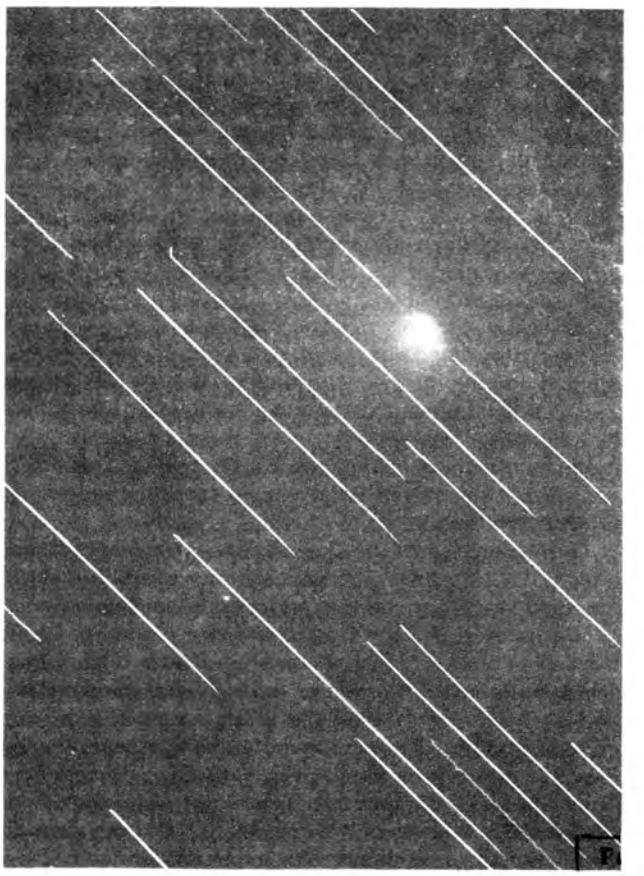
The exciting discovery of a new comet by the Infrared Astronomical Satellite on 26 April, and the object's subsequent near encounter with the Earth, was headline news all around the world. Ground-based telescopes and orbiting satellites—the International Ultraviolet Explorer, for instance—turned their collective gaze towards the comet as it swept past a mere 4½ million km away—the closest such approach for 200 years.

BIS Fellow Dr. John Davies was closely involved with the discovery at the Rutherford Appleton Laboratory in Oxfordshire. He takes up the story for *Spaceflight*:

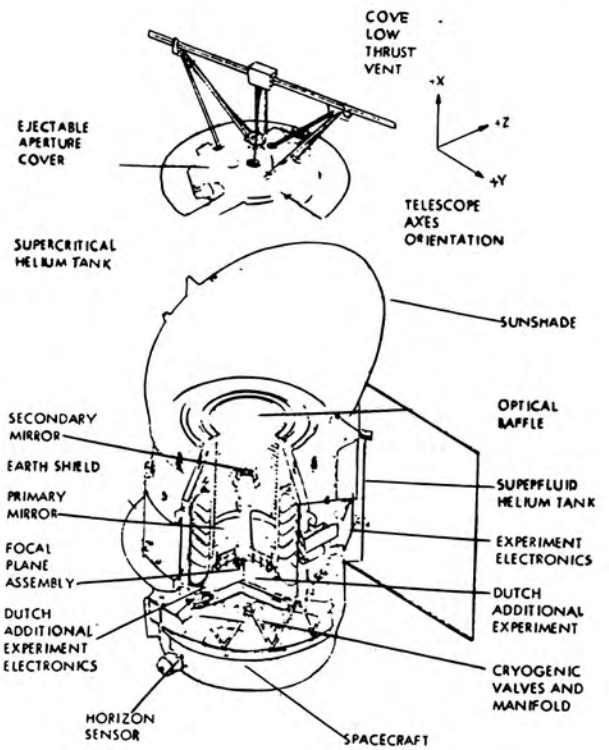
"The main mission of IRAS is to carry out an all-sky survey at a range of wavelengths, some of which do not penetrate the atmosphere. To ensure the reliability of this survey the orbit of IRAS is arranged so that each area of the sky is scanned twice, usually on consecutive orbits, and further repeat scans are made later in the mission. All souces which are not comfirmed at the same position are automatically rejected, since distant objects such as stars and galaxies remain inertially fixed.

"Following on initiative by UK astronomers, Simon Green of Leicester University and Brian Stewart of RAL developed computer software to search through these rejected sources to check for possible moving objects such as asteroids and comets.

"Since the beginning of the survey Simon Green and I have monitored the twice-daily computer-printout of possible fast moving objects searching for asteroids and comets. During this work large numbers of sources moving one or two arcminutes per hour have been detected. These have been clearly identified as main belt asteroids, many of which have been studied with ground-based telescopes.



Comet IRAS-Araki-Alcock on 8 May.



"It was on Wednesday 26th April that I noticed an unusual fast moving object in the constellation of Cygnus. The ratio of infrared fluxes allowed the temperature of the object to be estimated and this, together with its motion and high ecliptic lattitude, clearly indicated that it was an inner Solar System object. After consultation with Simon and members of the IRAS science team an alert telex was sent to six observatories around the world which had previously agreed to search for moving objects detected by IRAS. Rapid photographic confirmation of such objects is required to allow an orbit to be calculated for later observations.

"T. Oja, an observer at the Swedish Observatory in Uppsala exposed three photographic plates on the evening of April 27th and reported that the object was comet-like with a central condensation 15 to 20 arc seconds in diameter. The Smithsonian Astrophysical Observatory confirmed that it was a new comet independently discovered visually by G. Araki and G. Alcock on 3 May.

"According to convention the comet was named after the first three independent discoverers and will be known as IRAS-ARAKI-ALCOCK 1983.

Wanted. *Spaceflight* vols 1 to 7, 9, 10 and 13. Details to Roger Wheeler, 17 Rutland Road, Bournemouth, Dorset BH9 1EQ.

SOCIETY NEWS

DAEDALUS – 10 YEARS ON

On 10 January 1973 the BIS launched a small team into a study which is now a household word in astronautical circles: Project Daedalus. Daedalus was a fully integrated study of an interstellar mission, *albeit* a rather simple one – a two stage nuclear powered rocket to boost a robot (ie unmanned, fully automated) payload onto a flyby mission which would occur at about 13% of the speed of light.

Simple though this mission might be, it was enough to keep the Daedalus team occupied for five years, burning midnight oil, estranging themselves from friends and family and consuming astounding quantities of lubricative beverage in the course of the regular progress meetings held in popular hostelries. (It is hotly denied that this latter factor was in fact the reason the project took five years!).

To the surprise of the Daedalus team it was realised late in 1982 that the 10th anniversary of the project's founding was approaching, and a suitable reunion was duly organised. All the Daedalus team members (with the exception of Jim Strong who regrettably died during 1982) were invited, together with several people who had been associated with the study either at the time or subsequently. The group who actually attended was Penny Wright, Tony White, Gerry Webb, John Parfitt, Tony Martin, Tony Lawton, Tim Grant, Bill Dillon and Alan Bond (members of the Project) and David Viewing, Sandy Smith, Ian Ridpath, Mat Irvine and Enrico Coffey (all of whom gave a short talk).

The reunion occurred at BIS headquarters and took the form of a series of short presentations, punctuated by stops for refreshment and lunch. The participants are grateful to Len Carter and the HQ staff for providing the venue and for putting up with them for the day.

Tony Martin began the talks by examining the case for orbit based laser driven starships, a system which has been proposed as more practical than the Daedalus concept. This proposition was strongly refuted, with ample evidence to convince the most ardent advocate of lasers of their errors. Having set the scene, Penny Wright and Tony Lawton then silenced the gathering with the theory of the magnetic monopole engine. Here, as a consequence of grand unification theories, this able duo showed that if magnetic monopoles do exist, it would be possible to employ them to disrupt mass and use the derived energy to build a rocket (or ramjet) which would give Daedalus the aura of a Wright biplane.

Alan Bond took the opportunity to return everyone to Earth by describing some work on Worldships. These huge cylinders propelled by stupendous nuclear detonations would carry almost a million people and fly in fleets of 30 or 40. They could carry a typical European nation to the stars in a thousand years or so, but he

Taking a break from the discussions (from left) Bill Dillon, Tony Lawton, Ian Ridpath and Tony Martin.

Gathering of the clans. A reunion of the Daedalus team was held at Society HQ on 10 January.

declined to say which nation he had in mind. Ian Ridpath reinforced sobriety by outlining the NASA search plans which had been freshly approved. He outlined the parameters for the all-sky and selected site survey which made everyone realise that interstellar studies was rapidly coming of age.

Bob Parkinson made his presence felt, even in his absence (forced by his work) by having Gerry Webb read his paper "Alternative Space Drives or Farewell to the Millenium Falcon." The paper described Bob's new propulsion system which came as a rectangular box of classified tricks with four sturdy mounting lugs and plugs for electrical power and control signals. One could attach this to any vehicle having a power supply and have 100 per cent propulsive efficiency. Having shown that there were still problems he ended with the question "Whatever did the Millenium Falcon use anyway?"

Tim Grant outlined his personal computational program into various aspects of interstellar studies, covering diverse aspects such as reliability of unmanned probes, sociology, artificial intelligence and manned stellar missions. Gerry Webb continued the overall theme indicating his own thoughts on philosophy and sociology and the place of mankind in the galaxy, and outlined the "middle of the road/SDP/Guardian approach".

Sandy Smith discussed worldship disasters only too convincingly, resulting in the later defacement of many beermats as the questions of the effect of blazing worldship forests was wrestled with in more congenial surroundings.

The next speaker was Mat Irvine, who introduced the British Rail advanced passenger worldship which tilts going round stars and the London Transport worldship, following complaints from Alpha Centauri that the inhabitants waited 10,000 years for one and then 30 came along together! He also showed many fine slides of Daedalus models from "Spaceships of the Mind" including one vindicating the prophecy of the vehicle tumbling through the Galaxy at its mission's end, with the small change that it actually tumbled down Mat's stairs.

The next speaker, David Viewing, put in a rare appearance and, as only he can, blinded everyone with his clarity of thought and reasoning which was self evident when pointed out. By now the Daedalus team and guests had rediscovered their old techniques of heckling and baudy behaviour and, having sharpened up on the previous speaker, now attacked the final guest Enrico Coffey who tried to explain that artificial intelligence is still far from the real thing. However, surveying the now degenerating order in front of him, he almost changed his mind on this point.

During the course of the afternoon an interlude was provided by a visit from Italian television who wished to make a film item for the Italian equivalent of "Tomorrows World", and also a passing visit from Nigel Calder, the author of *Spaceships of the Mind*.

As the day wound to a close the team dispersed to their respective refuges to recall the gems with which they had been presented – except for a small hardy nucleus, that is, who, with bulldog determination carried the intellectual activity, perhaps with some not inexplicable distortion, into the early hours of the Project's second decade.

Space Frontiers Ltd.

SCIENCE MUSEUM CEREMONY

The Society was represented by its Executive Secretary, Len Carter, at a distinguished gathering of representatives of the communications industry at the Science Museum on 15 March. The occasion was to witness the opening of a new telecommunications wing by H.R.H. Prince Charles. The venue, filled with enormous replicas of engineering masterpieces of the past, was most impressive.

In a short speech to mark the opening, His Royal Highness stressed the importance, in this changing world, of making things intelligible to the young. He also urged that every endeavour be made to keep the UK at the forefront of technology and asked those present to consider, yet again, whether research in the UK was being carried out to greatest advantage and in the right conditions.

BIS FELLOW HONOURED

We congratulate BIS Fellow Major General Heinz Fuchs, Professor of Aerospace Medicine at Justus Liebig University on being honoured by the President of the Republic of South Africa, who awarded him the "Order of the Star of South Africa", an order established by HRH Queen Elizabeth in 1954.

WHAT'S NEW IN THE LIBRARY

New Brooms

The Terms of Reference of the Library Committee not only charge it to collect books and reports but also with responsibility for everything which can be classed as a "collection". This explains their concern in searching out models, recordings, pictures and slides, in fact anything that might be of an interesting space nature.

The last published Report contained a modest suggestion that the Committee should build up a collection of the sets of cards given free with various products. Those envisaged were really cigarette cards which used to appear in sets of 25 or 50.

Initially, the Committee had very little idea where such cards might be found but their work has since borne fruit and the sets secured so far are:

Year	Title	Issued By
1914	Those Pearls of Heaven	Players
1926	Romance of the Heavens	Wills
1956	Out into Space	Brooke-Bond
1956	Conquest of Space – Series A	Weetabix
1956	Conquest of Space – Series B	Weetabix
1967	Space	Anglo Confectionery
1968	Romance of the Heavens	Badshah Tea
1969	The Space Age	Brooke-Bond
1971	The Race into Space	Brooke-Bond

Two of the above sets, for example, turned out to have been prepared by none other than Len Carter, with paintings by David Hardy. He remembered preparing even earlier sets but, as they went to an Agent, has no idea where they eventually appeared. Ken Gatland, too, turned up as an originator of several sets.

Members who know of similar card sets, and where they might be found, should let the Executive Secretary know.

Where does it all come from?

Taking Stock

As the Library progresses so the Committee has to make positive efforts to find highly specialised and relatively rare books. It often seems like seeking a needle in a haystack, hence an appeal to members in

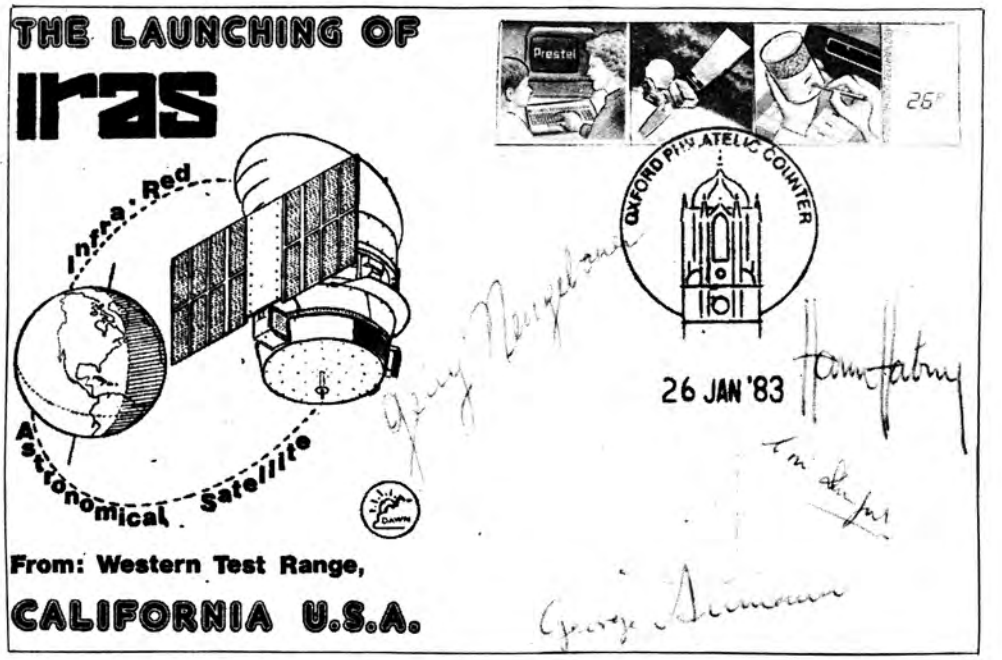
DESIDERATA*

The Library Committee will welcome help from members in acquiring the items listed below for the Society's Collection. Many of these were published in the USA and, hence, never readily available in the UK. Possibly they may still be picked up in second-hand bookshops or discovered in bookseller's catalogues. An appeal is made, particularly, to American members with access to such avenues to procure these items for us. Besides those listed, the Committee is seeking material on the use of rockets for non-space purposes e.g. pyrotechnics, signal rockets, etc., particularly if of early vintage.

Members with information on any of the items listed are urged to contact the Executive Secretary.

Author	Title	Publisher/Date
J. Blunck	Mars and its Satellites	Exposition Press, NY, 1977
V. F. Buchwald	Handbook of Iron Meteorites	Univ. of Calif. Press, 1975
M. Carpenter, *et al*	We Seven	Simon & Schuster, 1962
H. S. F. Cooper	Moonrocks	Dial, NY, 1970
S. Drake & C. D. O'Malley	The Controversy of the Comet of 1618	Univ. of Penn Press, 1960
F. Golden	Colonies in Space: The Next Giant Step	Harcourt Brace & Jovanovich, 1977
C. D. Hellman	The Comet of 1577	AMS Press, NY, 1944,
E. L. Krinov	Giant Meteorites	Pergamon Press, 1966
B. Mason	Meteorites	J. Wiley, NY, 1962
G. J. H. McCall	Meteorites and their Origins	J. Wiley, NY, 1973
A. J. Meadows	Early Solar Physics	Pergamon, 1970
Isaac Newton	Principia (1686); trans. by A. Mott	Univ. of Calif., 1962
J. P. Nichols	The Planet Neptune	John Johnstone, 1848
H. H. Nininger	Arizona's Meteorite Crater	World Press, Denver, 1956
R. S. Richardson	Getting Acquainted with Comets	McGraw-Hill, 1967
N. B. Richter	The Nature of Comets	Methuen, 1963
F. Zwicky	Catalogue of Galaxies and Clusters of Galaxies (6 vols)	Caltech

** We are indebted to Ray Ward for pointing out that this is the correct Latin word for "things desired".*



A recent addition to our collection of First Day Covers: the launch of the InfraRed Astronomical Satellite.

America, particularly, to help us find interesting books not available in the UK. Even so, our Library continues to grow, as the following table shows:

	As at 3.3.83	As at 9.3.82
Books	2,215	1,993
Reports	4,230	3,932
	6,445	5,925

Recent donations included several from Mr. H. de Koningh, two exceptionally valuable semi-historical volumes from Craig Waff, who turned out to be no less than the Assistant Executive Editor of Columbia University Press, a book by Tom O'Neill which we hadn't seen before and a classified list of satellites from W. J. Millard, who had prepared it himself.

Artefacts-wise, a number of crates containing Skylark rocket bays and other pieces arrived through the courtesy of SERC, with help from Gerry Webb. We were delighted to have these, but with reservations. It was doubtless easy to load them on a lorry, with a fork-lift truck, at the SERC end, but unloading them again at the Society's Offices was a sure recipe for hernias or bandy-legs, at least.

Space Covers

The Society intends to build up a collection of First Day Covers relating to Space events. These will provide a basis for subsequent Library displays so we would be glad to hear from any members with items like this who might consider donating them to the Society.

Rex Hall continued his donation of Soviet First Day Space Covers with a further batch (how he does it we'll never know) followed by David Horne who managed to accumulate some from a Soviet colleague, with the whole lot supplemented by some excellent pre-war rocket launch covers from Francis Field, his second in a row. Just as the Committee was congratulating itself on having achieved so much someone did a quick calculation on the number of different space covers around and came up with:

1,500 plus from the USSR, including First Day Covers, postal stationery and club covers.

1,300 from the USA, ranging from pre-Mercury to the Shuttle.

200 from France, beginning with their early programme though mainly from French Guyana, CNES, etc.

250 from Japan.

This makes a grand total of 3,250.

COUNCIL ENDORSES WORK OF THE LIBRARY COMMITTEE

The Council endorses the work of the Library Committee and fully supports its activities. They consider that the work of the Committee in endeavouring to secure material of an historical nature is most significant. Not only does it advance the interests of the Society but increases the fund of important material preserved for the astronautical community for posterity.

Some of this material is very rare. For this reason members, having the means to do so, are urged to consider providing financial support to sponsor future acquisitions.

The Council has been most gratified to see widespread support for the work of the Committee given by members and wishes to record, formally, its most sincere thanks to all who have responded.

Project Badges

A similar collection for display purposes will include badges issued to mark or provide personalised identification during space projects, including launch, test and similar functions. Those sought are ones that indicate both the name of the person attending and the space activity involved.

Items like this are usually thrown away after use but, if there are members who have kept them and are willing to part with them, please let us know.

Yesteryear

Trying to build up a representative collection of important early astronomical works which contributed so much to an awareness of the Heavens and led, eventually, to the development of space travel, has proved a formidable task.

Works which pre-date 1850 probably still abound but are not easy to locate. Max Wholey found one, by chance, in a Guildford bookshop. We were pleased to have this and hope that other members will rout around similarly, or even short-circuit things by simply asking the bookseller if he has any early works on astronomy in his rare book stock and then sending details to the Society.

Another plan was to put together a representative selection of early science fiction books, no doubt inspired by Fred Ordway's enthralling article on this topic in *Space Education* recently.

We got off to a tremendous start with a first edition copy of "The Brick Moon" story in the *His Level Best* collection by Edward Everett Hale (1873) donated by Captain Bob Freitag, and have since acquired several other books of early vintage. Members able to proffer practical advice or help in this project are invited to do so.

Another unique and entirely unexpected gift emerged from Kas Kasapoglu. He had a two-hour recording of an interview with the late Val Cleaver, a former Chairman of the Society who had been closely involved in the development of both the Blue Streak rocket and the establishment of ELDO.

Bill McLaughlin added a modern touch by bringing over an audio/visual Voyager slide presentation to Space '82. He also gave us a couple of short film sequences on the Voyager shots to Jupiter/Saturn which we were able to merge with other material to make a short film for the Society's education film programme.

Even more surprisingly, he produced a picture of several Roman coins, one of which showed a comet over the head of Julius Caesar. The comet actually appeared some time after his assassination and was thought to be his soul ascending to Heaven. Another comet appeared, this time in 17 BC, during the reign of Augustus. This was thought to be the return of Julius' soul once more! Both coins are really little bits of history. Bringing them to our attention enabled the Society to seek specimens for display in the Library.

A Roman coin showing the head of Augustus Caesar and the comet of 17 B.C.

British Museum

Seal of Approval

The President appeared at a meeting of the Library Committee, unexpectedly, no doubt to see what they were up to. Fortunately he chose a day when the Committee was in fine fettle and able to put up a good show. Not that he arrived emptyhanded. He produced a nice local artefact in the form of a very fine art noveau vase made by Florence James between 1902 and 1906 at the Doulton Factory which used to exist a few hundred yards down the road. It was a gift which the Committee were most happy to take into care.

They must have got a good school report at the following Council Meeting, too, for after reviewing activities over the past year, the Council congratulated the Committee on its work for the Society. Needless to say, the Committee were most flattered and hastily resurrected all the good intentions it had previously let drop by the wayside.

A Vote of Thanks

Once again, the thanks of many members are due to those Members of the Library Committee who have shouldered the responsibility of running the Library, manning it and dealing with a multitude of enquiries, besides all the tasks involved in cataloguing, book collection and individual searches to make sure that our Library will become something to be proud of. This involves a heavy demand upon their time. Their voluntary service in undertaking all these chores and opening the Library regularly for the convenience of members is greatly appreciated.

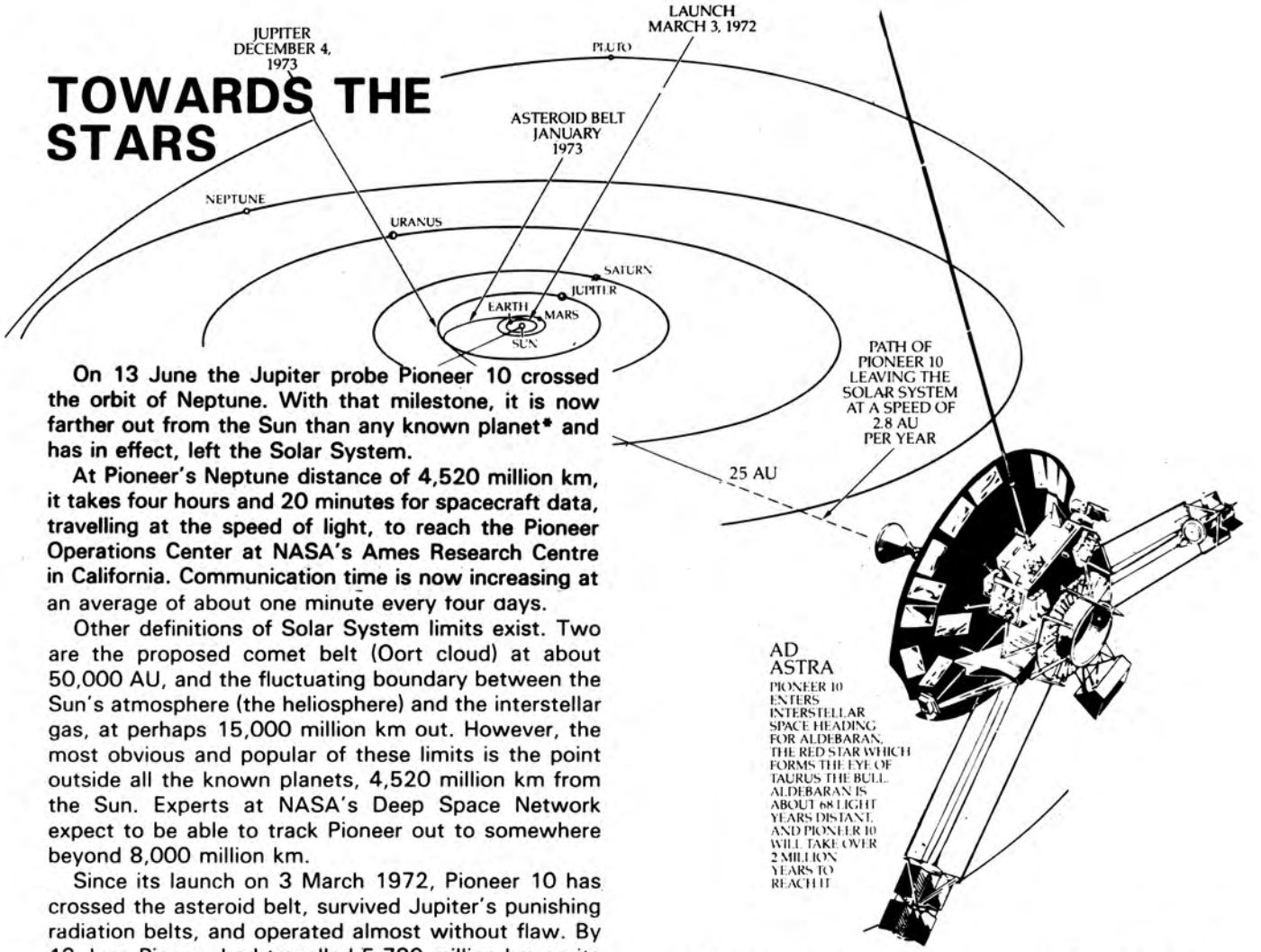
A SPECIAL MESSAGE TO MEMBERS APPROACHING RETIREMENT

Priceless collections of books and documents held by most organisations today began with gifts from some of their most dedicated members long ago. Our own Society ought to be in the same position, with collections built up in the same way. This is why the Library Committee seeks help from members who have already demonstrated support for our aims for most of their lives. They represent our greatest reservoir of goodwill and probably include many who would like to assist.

We would very much like to hear from members approaching retirement who might own collections on astronomy or space and who would be prepared to consider, eventually, presenting them to the Society to form the basis for our future Archives and to make sure that they will be recorded and preserved.

Please write to the Executive Secretary if you feel that you can help us in this work.

TOWARDS THE STARS


JUPITER
DECEMBER 4, 1973
LAUNCH
MARCH 3, 1972
PLUTO
ASTEROID BELT
JANUARY
1973
NEPTUNE
URANUS
SATURN
JUPITER
EARTH
MARS
SUN
PATH OF PIONEER 10 LEAVING THE SOLAR SYSTEM AT A SPEED OF 2.8 AU PER YEAR
25 AU
AD ASTRA
PIONEER 10 ENTERS INTERSTELLAR SPACE HEADING FOR ALDEBARAN, THE RED STAR WHICH FORMS THE EYE OF TAURUS THE BULL. ALDEBARAN IS ABOUT 68 LIGHT YEARS DISTANT, AND PIONEER 10 WILL TAKE OVER 2 MILLION YEARS TO REACH IT

On 13 June the Jupiter probe Pioneer 10 crossed the orbit of Neptune. With that milestone, it is now farther out from the Sun than any known planet* and has in effect, left the Solar System.

At Pioneer's Neptune distance of 4,520 million km, it takes four hours and 20 minutes for spacecraft data, travelling at the speed of light, to reach the Pioneer Operations Center at NASA's Ames Research Centre in California. Communication time is now increasing at an average of about one minute every four days.

Other definitions of Solar System limits exist. Two are the proposed comet belt (Oort cloud) at about 50,000 AU, and the fluctuating boundary between the Sun's atmosphere (the heliosphere) and the interstellar gas, at perhaps 15,000 million km out. However, the most obvious and popular of these limits is the point outside all the known planets, 4,520 million km from the Sun. Experts at NASA's Deep Space Network expect to be able to track Pioneer out to somewhere beyond 8,000 million km.

Since its launch on 3 March 1972, Pioneer 10 has crossed the asteroid belt, survived Jupiter's punishing radiation belts, and operated almost without flaw. By 13 June Pioneer had travelled 5,780 million km on its flight path, received more than 98,900 commands from Earth, and transmitted more than 126,000 million bits of scientific data.

New Jobs for Pioneer

With one exception, the far-travelling craft continues to function well, and is currently engaged in a new enterprise: defining the extent and behaviour of the Sun's extended atmosphere – the magnetic bubble which contains the Sun and the planets. This "bubble" in the interstellar medium is called the heliosphere.

Pioneer 10 tracking data are also being used to look for a possible dark star companion to the Sun. Unexplained deviations in the orbits of Uranus and Neptune point to a possible companion. Less likely, these deviations could be due to a relatively close-in 10th planet. Because of its great distance, Pioneer also provides a unique instrument for attempting the first detection of gravity waves employing enormously long wavelengths never before observable.

Despite damage from intense Jovian radiation, and hits by tiny micrometeoroids, plus 11 years of continuous operation, almost all systems are performing well. The magnetometer failed in 1975, but experimenters can calculate the interplanetary field from charged particle trajectories, magnetic data already gathered, and several correlations from five other Pioneer scientific instruments.

* *Though Pluto is normally the outermost planet, its orbit is so elongated that for the next 17 years it will be inside Neptune's orbit, and Pluto will never again catch up with Pioneer.*

Scientists await current spacecraft findings "with intense excitement," says Dr. James A. Van Allen of the University of Iowa, "because we think the Sun is typical of a majority of the stars in the universe. It's the only star we can measure from 'close up.' Finding the extent and exact mechanisms of the Sun's atmosphere will tell us a great deal about the Sun itself, about the interstellar gas surrounding the Solar System, and hence about stars in general."

The Heliosphere

The picture now emerging seems to show that the heliosphere is enormous, far larger than predicted. The heliosphere (created by the million-mile-an-hour solar wind, blowing out from the Sun in all directions) appears to be a tear-shaped magnetic bubble. The bubble is "streamlined" by the motion of the Solar System through the interstellar gas.

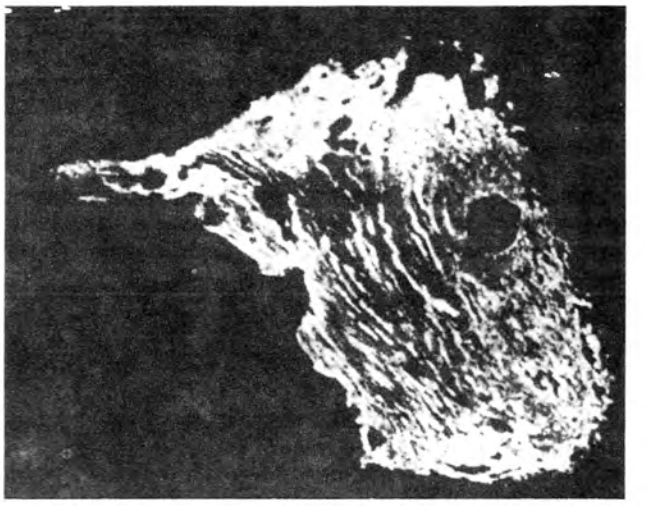
Pioneer is travelling "down the tail" of the heliosphere tear drop, looking for the boundary between the Sun's atmosphere and true interstellar space.

At the long-lived spacecraft's current distance, the Earth would be seen as a pin point of light, never more than 2.2 degrees away from a Sun still intensely bright. but no larger than a pin head.

Because of this huge distance, and the decline in brightness of the Sun, Pioneer's Sun sensor will not be able much longer to provide the "Sun pulse", which gives the rotational position of the spinning spacecraft several times a minute. However, NASA-Ames mission controllers have devised a method of making star maps with the Pioneer camera (Imaging Photopolarimeter) to provide the needed rotational and attitude data.

LUNAR & PLANETARY CONFERENCE

The Fourteenth Lunar and Planetary Science Conference, held at Houston in Texas during March, affirmed the continuing vitality of Solar System science despite financial problems and the recent lack of new deep space missions. Here, James D. Burke reports on some of the main sessions for *Spaceflight* . . .



A radar image, made with the 12.6 cm radar system at Arecibo Observatory in Puerto Rico, shows the Maxwell Montes mountain range on Venus, rising some 12 km above the mean planetary radius. The bands on the 1000 km-long range seem to be comparable with tectonic features on Earth. The dark "eye" might be a result of a volcanic process or impact.

Courtesy of
D. B. Campbell, J. W. Head, J. K. Harmon & A. A. Hine

An Overview

During the five-day conference there were, as usual, hundreds of papers, so this report can cover only the highlights. To me the most interesting sessions were those on the exploration of Venus, new meteorite discoveries, lunar remote sensing, and the early history of the Solar System. In addition there was a special public session on the question of future lunar programmes.

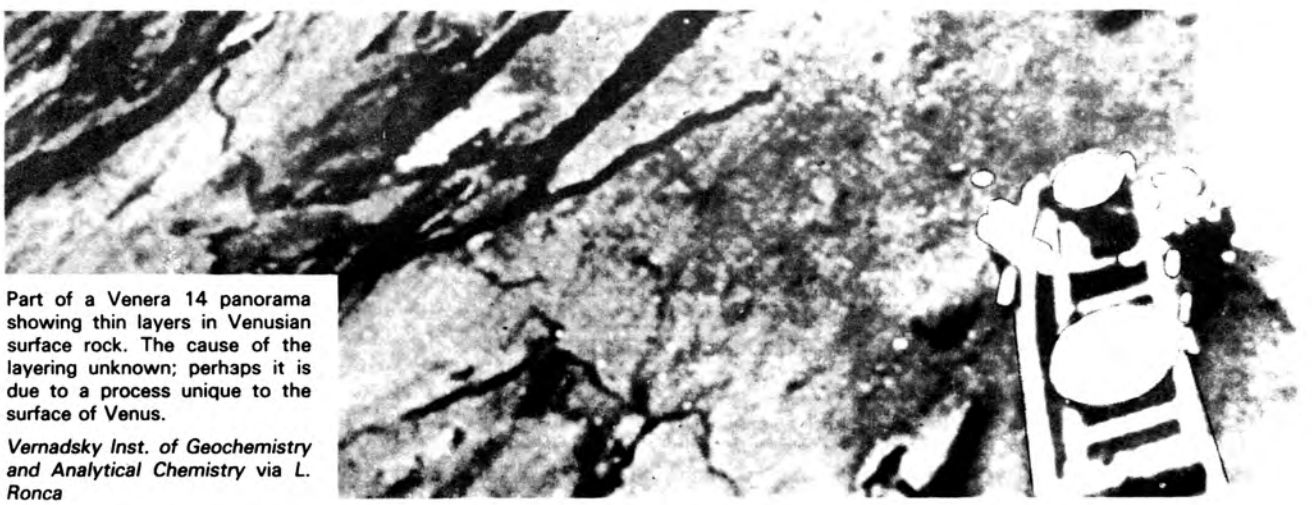
Venus Exploration

Continuing improvements in Earth-based radar techniques at the Arecibo radio observatory have resulted in the discovery of multiple bands of high and low reflectivity in some of the mountainous regions of Venus. These could correspond to folded mountain belts such as the Appalachians (in the USA) on Earth, whose shape and lateral dimensions they closely resemble, or they could be the result of faulting or extensional tectonics as in the basin and range topography of Nevada. The resolution of Venus radar altimetry (either from the Pioneer Venus Orbiter or from Earth) is not yet good enough to show the topographic details that could help to decide among these hypotheses. Thus these possible mountain belts offer an exciting target for future orbital radar missions to Venus.

Soviet delegates and their American colleagues gave further reports on the findings of Venera 13 and 14 and the Pioneer Venus Orbiter and probes. Venera 14 panoramas have been processed to bring out more details of the thinly-layered, alkaline basalt rocks at the Venera 14 landing site. Atmospheric composition data from the Veneras and from Pioneer Venus strongly suggest that Venus once had an ocean, which boiled away in the runaway greenhouse event that produced the present atmosphere.

New Meteorite Discoveries

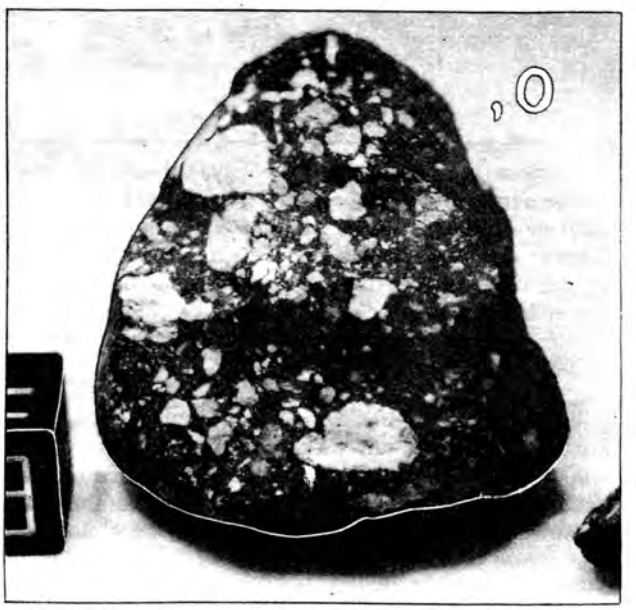
On their last snowmobile traverse of the 1981–82 Antarctic meteorite collecting season, the team exploring an Allan Hills ice field picked up a small rock now known as ALHA 81005. Petrographic, mineralogical, chemical and isotopic analyses now have shown that ALHA 81005 is almost certainly a fragment of the lunar highland crust, closely resembling (but not identical to) some of the breccia samples collected by the



Part of a Venera 14 panorama showing thin layers in Venusian surface rock. The cause of the layering unknown; perhaps it is due to a process unique to the surface of Venus.

Vernadsky Inst. of Geochemistry and Analytical Chemistry via *L. Ronca*

Apollo 16 and 17 astronauts. Thus we now possess a sample of another part of the lunar surface. What part? That is as yet unknown, but some lines of evidence point to the Moon's eastern highlands, where the recent crater Giordano Bruno is a candidate site, or to the extensive far-side highlands. The discovery that an impact can eject relatively-undamaged fragments of the Moon into orbits reaching Earth will greatly stimulate further meteorite searches. It also lends validity to the idea that certain other meteorites known as the Shergottites, Nakhlites, and Chassignites, or SNC for short, may have been similarly delivered to Earth from Mars [a more detailed report on these specimens follows this section – Ed.] Though the SNC evidence is not so persuasive as that for ALHA 81005, in part because the latter can be directly compared with Apollo samples, a Martian origin of the SNC rocks is possible and will lead to continuing excitement among "meteoriticists".



Antarctic meteorite ALHA 81005 which has the characteristics of a lunar highland sample in every analysis so far carried out.

NASA via *M. Duke, JSC*

Lunar Remote Sensing

Undaunted by the continuing absence of the one lunar mission most favoured by all lunar scientists – the geochemical polar orbiter – some investigators are using Earth-based telescopes to refine the technique of visible and near-infrared reflectance spectroscopy for mapping mineral zones on the Moon's near side. As just one example of the interesting findings emerging from this research, it appears that the central peaks of the crater Copernicus have a distinctive composition rich in the mineral olivine, possibly an important component in the mantle of the Moon. Thus the impact that formed the crater may have brought up material from beneath the lunar crust.

Early Solar System History

As a result of determined work by scientists in many fields a picture is beginning to emerge on the formation of the Solar System. The fundamental observations are

(1) the Solar System's present architecture (a slowly-rotating star with planets in circular, coplanar orbits),

(2) the chemistry and physics of the Sun and planets,

(3) the character of meteorites, whose isotopes reveal that they solidified early in the history of the system.

Though many details are still vigorously debated, there is general agreement that by around 4,600 million years ago a cloud of gas and dust had collapsed into a disc from which the Sun and planets formed. At the Houston conference a number of papers dealt with the present evidence, both theoretical and observational, as to the thermal, chemical and dynamical processes in this solar nebula. Some of the most intriguing hints come from minutely-detailed and precise analyses of small objects found in meteorites.

The accompanying picture shows a typical example: it is a section of rock containing chondrules, the small glassy spheres that give the chondritic meteorites their name. Some scientists believe that the chondrules were molten droplets in the nebula which quickly solidified and were then surrounded by other materials with much lower melting points as the system evolved and cooled. Other meteoritic textures also show "high-melting inclusions in a low-temperature matrix", and the isotopes in these inclusions have led scientists a merry chase: they include the daughter products of ancient, short-lived nuclides that most probably were made in a supernova explosion. Did the shock wave from a nearby supernova start the collapse of the pre-solar cloud? That model is subject to lively debate, but all parties agree that the presence of these various nuclides, in isotopic proportions very different from those of other Solar System matter, in meteorite grains betrays a fast-moving and puzzling sequence of events at the birth of the Sun and its planets.

Special Lunar Sessions

On one afternoon and one evening during the conference, special public sessions were held on the question of Man's return to the Moon. Hans Mark, NASA Deputy Administrator, quoted Wernher von Braun on the history of Antarctic exploration and settlement as a model for what may happen on the Moon, and emphasised the importance in both cases of the technology for getting there. Other speakers then discussed the scientific, engineering and policy questions surrounding a renewed lunar programme. Discovery, evaluation, processing and the use of lunar resources are central elements in most proposals for future Moon programmes. In view of the known differences in composition between the Moon and some asteroids, an ideal programme would probably include use of materials from both sources.

The discussions can be summarised by saying that we certainly cannot see, today, a clear path to the renewed, wide public support that would allow a new manned lunar programme. However, we can see preliminary activities, some of them already started for other reasons, that could lead ultimately to a return to the Moon.

METEORITES FROM MARS?

By the Staff of NASA

A planetary science controversy, which has been active since the 1970's, may now be taking a new turn as recent studies at NASA's Johnson Space Center in Houston can provide new evidence that up to nine meteorites found on Earth originally came from Mars.

If the idea of a Martian origin is correct (and scientists are quick to point out that the only conclusive proof would be to collect samples from the surface of Mars itself) the meteorites in question could be the most important extraterrestrial rocks studied here since the first return of lunar samples in 1969.

The scientific detective story goes all the way back to 1815, when a meteorite that fell near Chassigny in France was found.

More than a century later, it was discovered that this meteorite is fundamentally different from nearly all of the thousands of meteorites found on Earth: it is nearly 3000 million years younger. Another of these unique meteorites was found in 1865 at Shergotty in India.

Because they were slightly different in composition, both the Chassigny and Shergotty samples became the first members of two rare classes of meteorites, the chassignites and the shergottites. In 1911, a similar specimen fell near Nakhla in Egypt (killing a dog!). It also became the first of a class of meteorites, the nakhlites.

The nine so-called SNC meteorites that make up these three classes (four shergottites, three nakhlites and two chassignites) have been found around the world in such places as Antarctica, Brazil, Nigeria and the United States.

They are unique chiefly because their age, only 1300 million years, is incredibly young in comparison to other meteorites, all of which date back to the formation of the Solar System about 4500 million years ago. The SNC meteorites, being 3000 million years younger, appear to have come from a different source; the others apparently formed in the asteroid belt between Mars and Jupiter.

A PIECE OF THE MOON?

When scientists picked up rock specimen ALHA 81005 on an Antarctic expedition in January 1982 little did they realise they were probably handling a 30g piece of the Moon. Now, all of their tests point to a lunar origin – possibly on the previously-unsampled far side. It seems that the material sat on the lunar surface for 100 million years, was buried and then blasted Earthwards by a large meteorite impact 100,000 years ago.

An Antarctic meteorite thought to originate from Mars.

NASA, courtesy of M. Duke, JSC

When these unusually low ages were discovered in the 1960's, the real debate as to the cause began.

They are all igneous rocks, which means they cooled and crystallized from molten lava. Volcanic eruptions about 1300 million years ago only added to the mystery, for there was no obvious planetary source for such young volcanic activity. By that time, the Moon's volcanic activity had long since ceased and none of the more distant asteroids seem large enough to have generated prolonged volcanism (the asteroid Vesta has been suggested, rather diffidently, as a possible source).

Mars, however, is a large enough world to have generated the internal heat for relatively young volcanic activity.

"In the pre-Apollo 11 days, there was a round of conjecture about what type of material might come from the Moon,' said Dr. Donald Bogard of Johnson's Planetary and Earth Science Division (PESD), which manages all of the samples returned from the Moon during the Apollo programme. "It was suggested that certain types of meteorites might be like lunar material. So conjecture on something coming from the Moon is not new. That of Martian origin, however, is more recent."

These speculations were given increasing force in the 1970's, when NASA's Mariner 9 and Viking Orbiters returned pictures of numerous volcanic landforms on Mars, many of which were about 1000 to 3000 million years old – about the age of the SNC meteorites.

In the past three years, studies of the shergottite group added important new evidence. All four of the samples (one from India, one from Nigeria and two

Mars – source of meteorites? This is the first picture ever taken from the surface of the Red Planet, 20 July 1976.

from the Antarctic) were found to have been subjected to intense shock waves, like those generated by intense meteorite impacts about 180 million years ago. Moreover, all of the shergotittes were also exposed to cosmic ray bombardment in space as small fragments about 2 million years ago. "An interpretation of those ages," said Dr. Lawrence Nyquist of Johnson, "is that these samples cooled from molten rock 1300 million years ago, were somehow ejected from a parent planet 180 million years ago as a large block more than 2 m across, and that small fragments broke off in space about 2 million years ago. Those fragments later landed on Earth."

But how did they get here? More perplexing, how did they leave the parent body in the first place? The first serious suggestion that Mars was the source was considered improbable by theoreticians. How, they wanted to know, could a block of material escape the gravity field of Mars? A meteorite capable of imparting the necessary velocity (3.7 km/s), they said, would more likely vaporize rather than eject surface rocks. How could such ejected rocks penetrate Mars' thin but resistant atmosphere? And even if such a collision could send chunks of rock flying off into space from Mars, then why have not samples from the much closer Moon been similarly propelled to Earth and found?

At the Lunar and Planetary Science Conference in Houston last March, Nyquist presented a paper which suggested how the samples might have reached Earth from Mars. Drawing on past research, he suggested that a large meteorite striking Mars with a high enough velocity and a low angle of impact (about 15 degrees from the surface) could impact and then ricochet at high velocity, partly vaporizing itself in the process. The resulting vapour cloud would carry with it pieces of the Martian surface, accelerating them to the high escape velocity needed to leave the planet.

This mechanism could explain how rocks are blown into space from the Martian surface, but then why haven't scientists discovered rocks on Earth blasted from our nearby Moon? Such grazing meteorite impacts must also occur there and the crater Messier is generally considered as the classic example, with ejecta spread around it in a typical "butterfly" patterns.

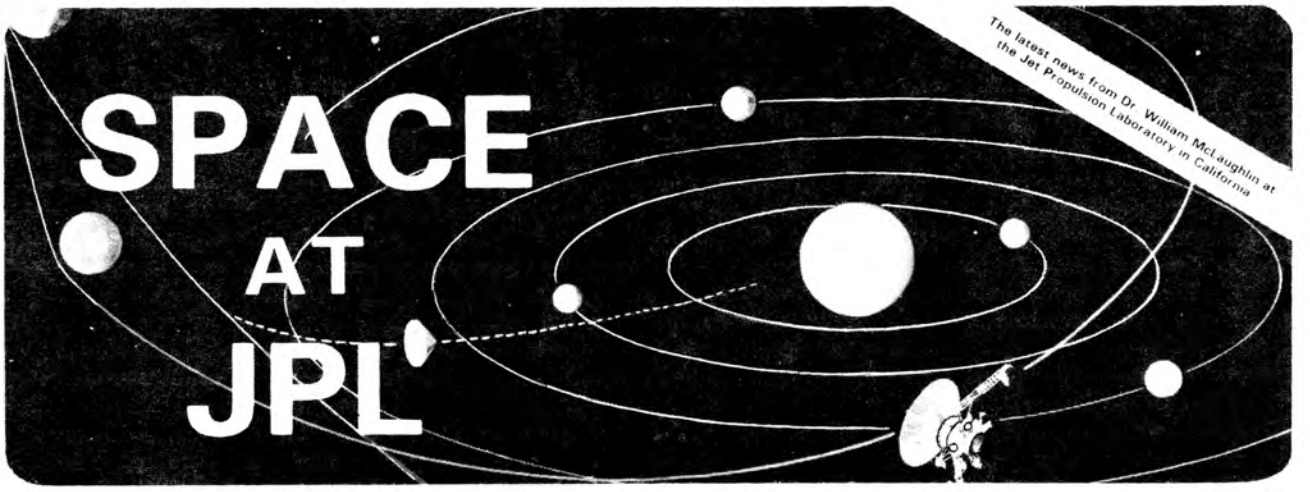
The answer might have been found recently in Antarctica. A small meteorite, weighing only about 30g, was recovered last year from a desolate area called Elephant Moraine. At a first glance, this sample seemed identical to rocks returned from the lunar highlands by Apollos 15, 16 and 17.

Although the scientists actively studying this sample are not yet convinced that it comes from the Moon, they should be able to settle the question by comparing its mineral composition, chemistry and age with definite lunar samples. If the rock does come from the Moon, it seems possible that similar impacts could have sent us rocks from Mars as well.

Nyquist believes the possible lunar sample found in Antarctica represents further circumstantial evidence for his theory, but, he adds, that even without this find, there is an explanation for the near-absence of lunar samples on Earth and the apparent relative abundance of Martian ones. The difference arises from the simple fact that it takes much longer for a meteorite to travel from Mars to Earth than from the Moon. An impact large enough to propel rocks into space occurs on either Mars or the Moon only about every 100 million years, he says, and the Mars-to-Earth travel time is more than 100 million years. This means that there is an essentially steady flow of small amounts of material coming from Mars. A rock blasted from the Moon, on the other hand, would be quickly swept up by the Earth's gravity, probably within a few days, and the lifetimes of stony meteorites exposed to terrestrial weather is at most only a few hundred years.

Another Antarctic meteorite, a shergottite collected in 1979, also from the Elephant Mcraine region near the US McMurdo Base, contained traces of the noble gases (argon, krypton, xenon, etc.) similar to those measured on Mars by the Viking landers. Isotopic patterns are also close to what the Viking landers measured. Argon-40, for example (not the more common argon-38), is anomalously plentiful on Mars, and the similar argon-40 and helium-4 abundances found in the Antarctic meteorite lead to a strong suggestion of Martian origin.

"The only conclusive thing would be to go to Mars and find out," said Planetary and Earth Sciences Division Chief Dr. Michael Duke. What is sure is that the detective work and the debates will continue until that day 20 or 30 years hence when either a human or a robot is able to bring a piece of the Red Planet back to Earth where the question can be answered once and for all.

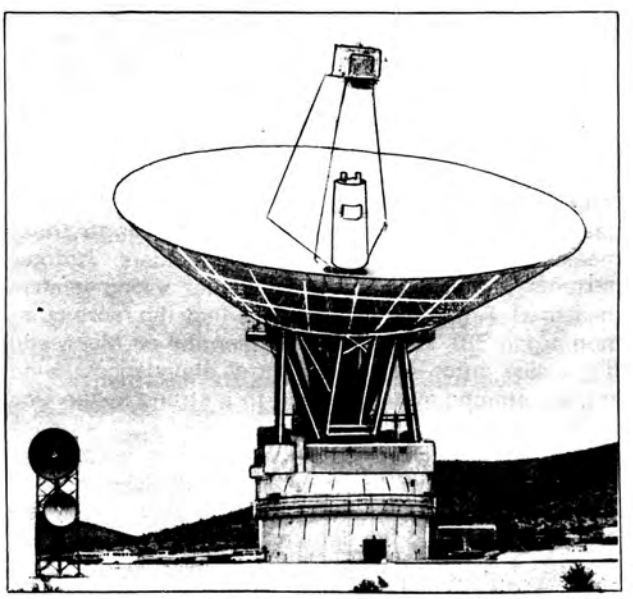


SETI

The Search for Extraterrestrial Intelligence (SETI) is alive and well at JPL with a modest but efficient programme under development in order to search for signs of intelligent life beyond the Solar System. This year $1.5 million is being invested by NASA in a joint JPL/Ames Research Center programme of research and development. The effort, with support from Stanford University in California, will last for five years and then be phased into a ten-year search for extraterrestrial intelligence, from approximately 1987 to 1997.

The purposes of the research and development phase are to test the observing equipment, strategies, techniques and the algorithms for finding potential signals in the data. Evaluation of observing sites will also be undertaken. The principal sites are to be Arecibo and the Deep Space Network (DSN) stations of JPL, especially the Goldstone station. Eventually, the DSN station in Australia will be required in order to achieve coverage in both the northern and southern portions of the celestial sphere.

After completion of the research and development phase, the observing programme will feature both an all-sky search and a targeted (looking at specific objects) search.



The 64 m antenna of JPL's Goldstone station will be used in a carefully-designed search for intelligent signals of extraterrestrial origin.

The all-sky search for signals of intelligent origin include a search-frequency range for the radio receivers of 1 to 10 GHz (corresponding to the wavelength range of 30 to 3 cm, which includes the "waterhole region" proposed by B. Oliver as a likely region of the electromagnetic spectrum for signalling purposes). Within this frequency range a resolution of 32 kHz will be possible, and the radio receivers will be able to detect signals as faint as 10^{-23} watts per square metre.

The targeted portion of the search will focus on stars from spectral classes F, G and K (the Sun is a G) within 25 light years of Earth – giving us about 700 stars to inspect. The frequency range of 1 to 3 GHz with 1 kHz resolution and a sensitivity of 10^{-27} watts per square metre will be scanned. With this sensitivity, a 100 million watt transmitter could be detected 10 light years away if it were radiating equally in all directions. Of course, much weaker transmitters could be detected if the beam were directed specifically towards Earth; for a signal beam confined to about one square degree and pointed toward Earth, 2,500 watts at 10 light years would suffice. In addition to the selected, Sun-like stars, several other objects of interest will be monitored: the Galactic centre, the Magellanic clouds, and some external galaxies.

The effort at JPL is led by Drs. Michael Klein (Project Manager) and Sam Gulkis (Project Scientist) with Drs. John Billingham and John Wolfe, their respective counterparts at Ames.

AN AIRCRAFT FOR MARS

Detailed reconnaissance of the Moon and planets has mimicked exploration of the Earth in some ways: surveillance satellites have orbited three bodies, ground vehicles have been employed, remote stations established, and man has walked on the Moon. To date no aircraft has flown in a planetary atmosphere, but there is no technological barrier to such a flight, and several mission studies have shown the benefits that could accrue from its in planetary exploration. This month's look at an advanced-concept mission focusses on such a craft in the Martian environment.

An aircraft could operate either as a cruiser, spending its entire useful life airborne, or as a soft lander. In the

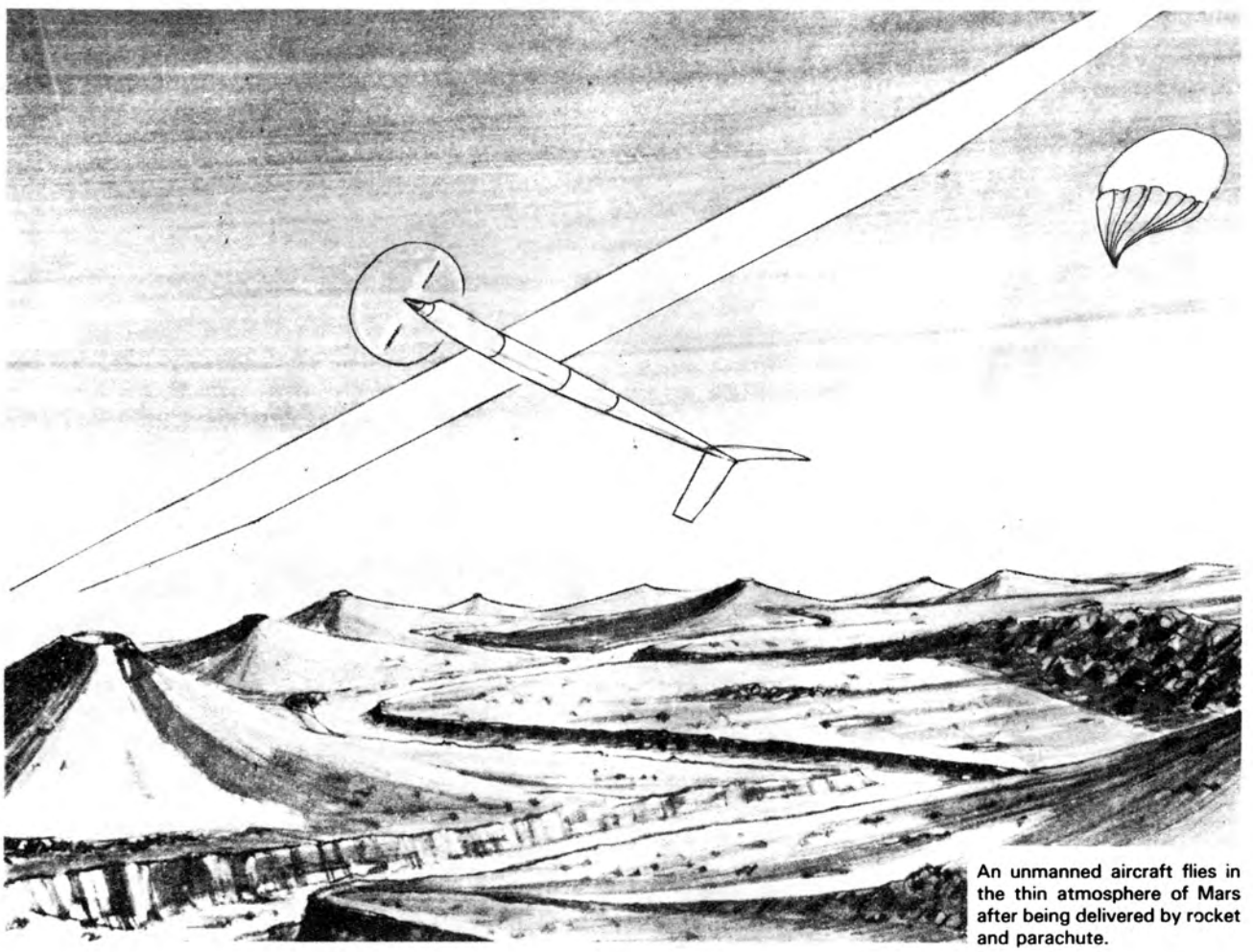
first role it would act much as its Earthly counterpart by conducting photographic, magnetic and geochemical surveys and doing meteorological studies. The extensive canyon system of Mars would be a particularly attractive target. An aircraft that could land and then take off again would have many useful functions: gathering samples from a large area and delivering them to a central site for analysis or return to Earth; deploying equipment at widely dispersed points (seismometers or weather stations, for example); searching for life or water at preferred sites. Like a swarm of insects, a fleet could cover large regions of the Martian surface and collect vast amounts of scientific information.

One mission scenario would carry a total of 12 winged craft to Mars inside three separate spacecraft. The aircraft would be deorbited from their hosts at about 500 km altitude and enter the thin, upper reaches of the Martian atmosphere, each encased in a protective aeroshell. At less than 10 km from the surface a parachute system would deploy, slowing the aeroshell and allowing the aircraft to free itself; its engine would start and it would fly off. The spacecraft would remain in orbit about Mars to form a system of communications satellites to transmit the data gathered by the aircraft back to Earth.

Since the atmosphere of Mars is mainly carbon dioxide, the engine could not be a conventional air-breathing type. Although nuclear and solar-electric powered vehicles hold some promise, a hydrazine piston engine is quite feasible and has been successfully used in the unmanned "Mini-Sniffer" research aircraft of NASA's Dryden Flight Research Center in California. Another difficulty with the Martian atmosphere is its low density; at ground level has the same density as our atmosphere at 30 km. Hence, a large wing area must be used, although the lesser Martian gravity somewhat compensates for the thinness of its atmosphere.

Performance is strongly dependent upon design tradeoffs, but studies have shown that total cruising ranges of 5,000 to 10,000 km are not unreasonable. A flight ceiling for cruises is about 15 km high; above this the atmosphere is too tenuous to provide adequate lift.

No Mars mission is currently funded within NASA. However, it is certainly only a matter of time before we return to that planet with rocket and, perhaps, aircraft. Even now it is possible to go there with the poet laureate of Mars, Ray Bradbury, "Now it was decelerating with metal efficiency in the upper Martian atmospheres. It was still a thing of beauty and strength. It had moved in the midnight waters of space like a pale sea leviathan . . ."



An unmanned aircraft flies in the thin atmosphere of Mars after being delivered by rocket and parachute.

VENUS RADAR MAPPER

The Reagan administration included a $29 million item for fiscal year 1984 (begins 1 October 1983) for the Venus Radar Mapper (VRM) mission. This $300 million project, managed by JPL for NASA, was developed from the ashes of the old Venus Orbiting Imaging Radar (VOIR) project, which had been cancelled by the administration. The VRM project still requires approval from Congress before the financial road is clear.

The plan is to launch the spacecraft from the Shuttle using a Centaur upper stage in April 1988 for a July 1988 arrival at Venus. Most of the planet would then be mapped to about 1 km resolution with a synthetic aperture radar during 243 days in orbit (see the December 1982 "Space at JPL" for further details).

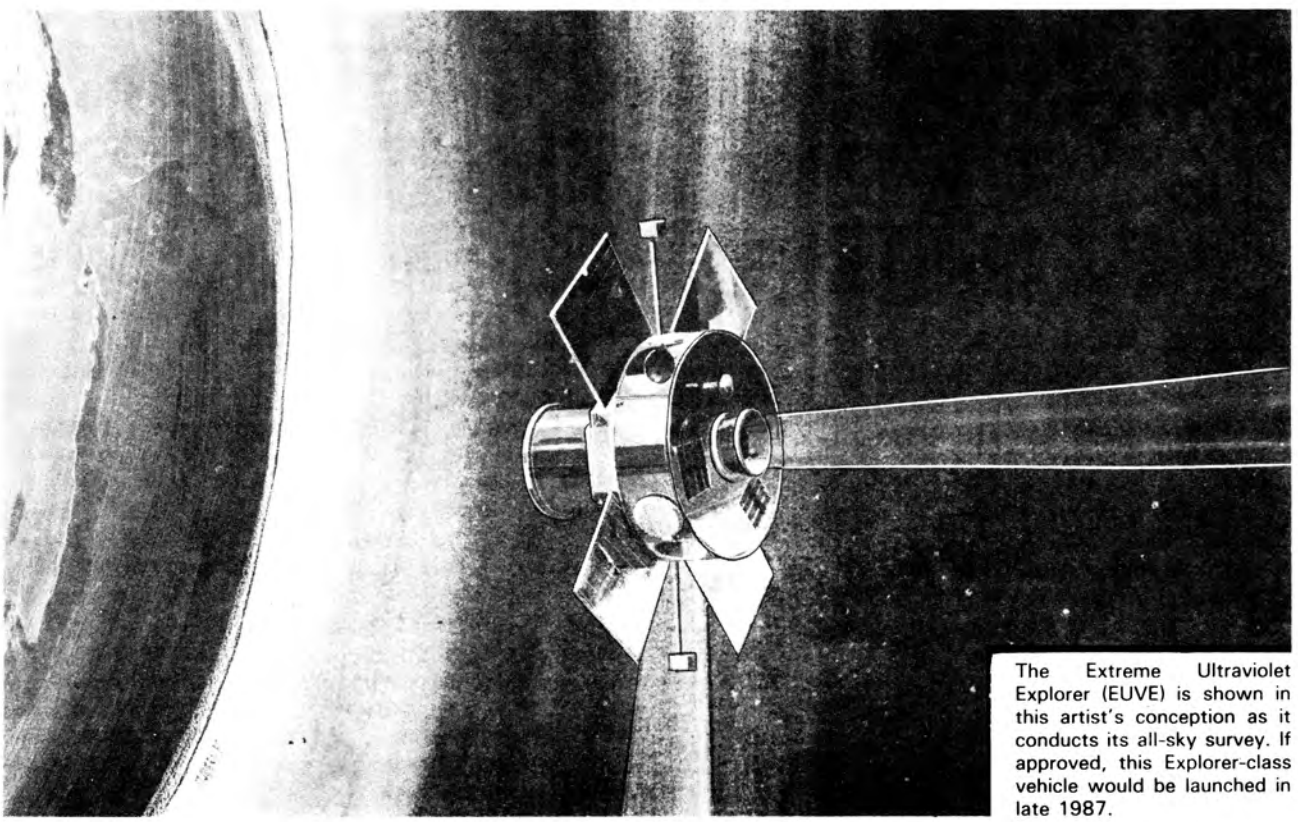
The project manager, John Gerpheide, and his JPL team were excited over the prospect of developing and flying VRM. Gerpheide said in a recent interview, "We're looking forward to the year ahead. The contractors are on board, the pre-project phases are complete and we're ready to go (with development of the project) on 1 October. We've gotten our team together defining requirements and writing contracts. We're geared up to develop the programme on time and on cost!" In addition to the intrinsic value of the VRM project, its inclusion in the Presidential budget is an unmistakable signal that the Reagan administration does envisage a programme of planetary exploration. VRM is the first planetary project approved since the Galileo project in 1978. Now it must be seen whether Congress is of the same temper as the Administration on this subject.

EUVE MOVES AHEAD

Since the March edition of this column, when a basic description of the proposed Extreme Ultraviolet Explorer (EUVE) satellite was given, an important change has occurred: a spectrometer has been added to the science payload to complement the existing four telescopes to be used for the all-sky survey.

The EUV band (100-1000 Å) is one of the last portions of the spectrum to be explored by astronomers (one Angstrom Å is equal to 10^{-8} m and is a commonly used measure for the wavelength of light). EUV astronomy is such a new branch of that ancient science that only nine EUV sources are known at present! Six are stellar objects and the other three are Jupiter, Saturn and Saturn's largest satellite, Titan. It is anticipated that EUVE will greatly enlarge this data base, perhaps detecting several hundred new sources in the extreme ultraviolet. The brightest are expected to be hot, white dwarfs; the most numerous sources will probably be the coronae of stars. However, as with all new branches of astronomy, there are high hopes that unexpected discoveries of new kinds of sources of EUV will be made.

During the first six months of the mission (with a proposed launch in late 1987), three telescopes mounted perpendicular to the satellite's spin axis will conduct a survey of the entire sky in the spectral range from 100 to 1000 Å. The fourth telescope pointing along the spin axis will conduct a deep-sky survey of a more restricted region of the celestial sphere and will share half of the photons that it collects with the newly-added spectrometer. This limited deep survey



The Extreme Ultraviolet Explorer (EUVE) is shown in this artist's conception as it conducts its all-sky survey. If approved, this Explorer-class vehicle would be launched in late 1987.

will search for new kinds of sources that are below the threshold of the all-sky survey.

The function of a spectrometer is to make a detailed analysis of the distribution of energy at various wavelengths of an astronomical source. From this analysis, the chemistry and structure of the source can be better understood. The addition of the spectrometer to EUVE will allow astronomers to follow up discoveries in the all-sky survey with detailed studies of individual stars. The usefulness of this kind of spectral observation in the EUV has been well demonstrated in solar EUV work. Because of the large interest in the potential results from the EUVE spectrometer, it will be made available to the entire astronomical community through a Guest Observer Programme.

The EUV spectrometer is actually a set of three spectrometers which operate over the range from 80 to 760 Å to a resolution of 1 part in 100, e.g., at 100 Å the wavelength of a spectral feature that is emitted by the source could be located to within 1 Å. It would require 20 minutes of observation time to acquire the spectrum of the brightest known EUV source, HZ-43, while fainter sources might take up to one week of "night time" observing (EUVE collects data only while the satellite is in the Earth's shadow).

Ron Ploszaj of JPL has replaced John Paulson, who recently retired from the Laboratory, as Project Manager. Dr. Stuart Bowyer of the Space Sciences Laboratory at the University of California, Berkeley (UCB) is the Principal Investigator, and Dr. Roger Malina of UCB is the Project Scientist. The UCB Project Manager is Henry Heetderks. EUVE is being managed by JPL for NASA's Office of Space Science and Applications.

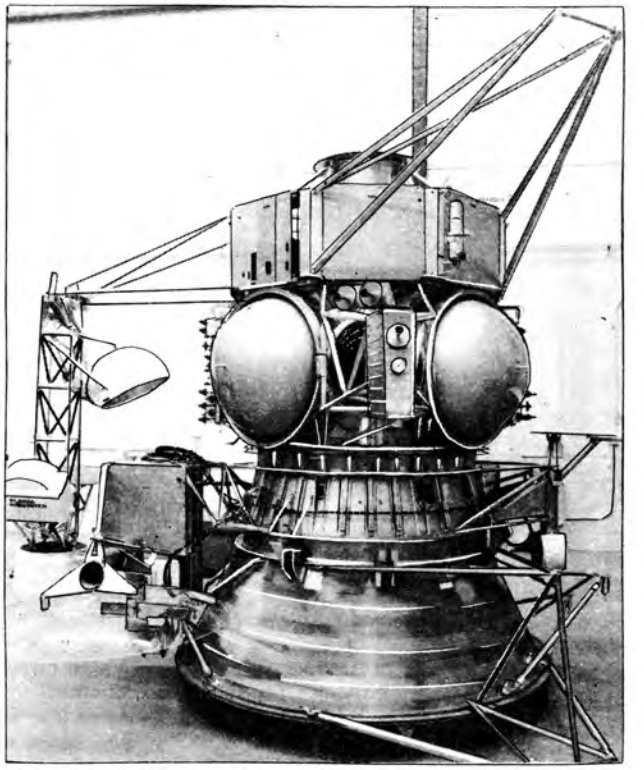
GALILEO NOTES

The Laboratory's Galileo project, which will send an Orbiter and Probe to Jupiter starting with a 1986 Shuttle/Centaur launch, was described in detail in the July-August 1982 issue of *Spaceflight*. Since the project is under continuous development it is appropriate to add notes from time to time.

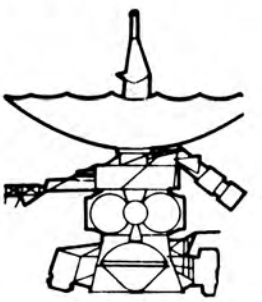
Integration and system testing of the Orbiter began at JPL this spring and is scheduled to last for 20 months. In the words of project manager John Casani, "The next 20 months will encompass the arduous task of checking, testing and retesting the spacecraft, learning its idiosyncrasies and preparing it, and ourselves, for flight."

The Galileo Probe is the responsibility of the Ames Research Center and has been in system integration since the spring of 1982. It is scheduled for delivery to JPL this August when integration with the Orbiter will begin. After a month's testing it will be delivered to the Hughes Aircraft Company for work and further testing and then be returned to JPL in January 1984.

One instrument aboard the Galileo Probe will be the nephelometer (from the Greek for cloud: nephele). It will be used to measure the physical structure of Jupiter's clouds: the location of cloud layers and the size, concentration and shape of cloud particles. It is expected that the Probe will fall through two and perhaps three major cloud layers. Similar instruments flew on the Pioneer Venus Probes in 1978.



This full-scale mockup of the Galileo Orbiter (minus its high-gain antenna) was put together to help with the configuration, cabling and blanketing design.



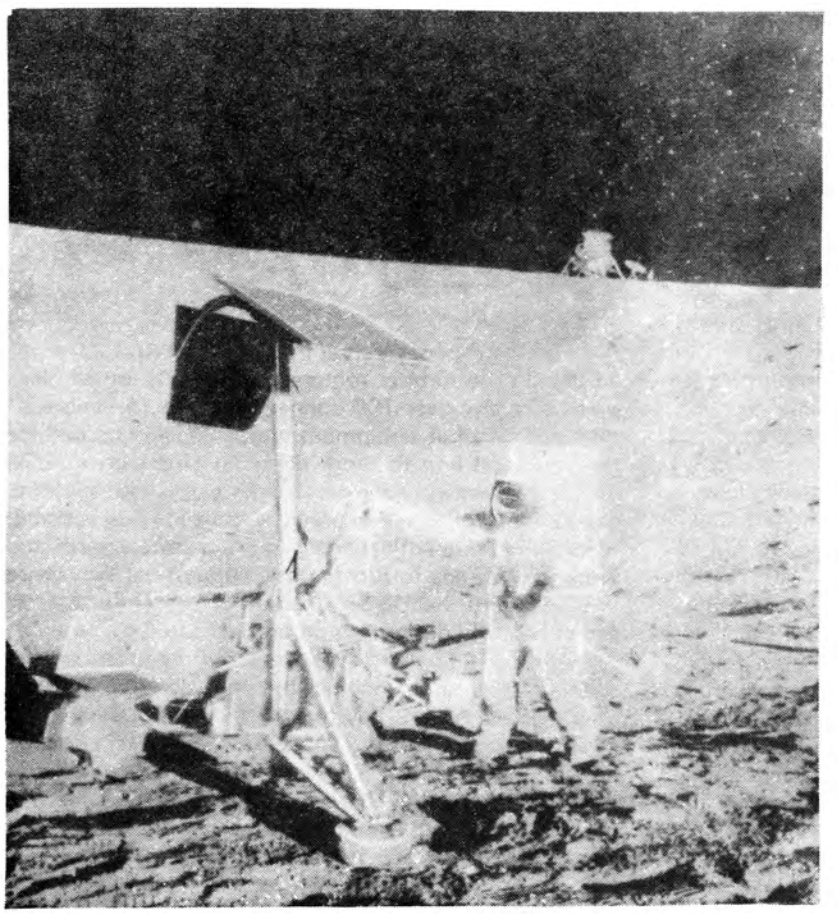
The Galileo Orbiter requires almost 7½ km of electrical wire and over 700 connectors. The 15 "cablers" that installed this equipment were specially trained for the task and had to work 60-hour weeks on a split-shift schedule in order to complete the job on time. Quality control is extremely important for this exacting work, and frequently photographs were taken of the work in progress to provide documentation. Each wire and connector has to be shielded to protect it against the severe radiation hazards around Jupiter.

One of the final subsystems to be installed on the spacecraft before launch will be the thermal blanketing. This serves several purposes: retention of heat in several vital parts of the spacecraft, protection against electrostatic discharge, and protection against micrometeoroid impacts. There will be nearly 300 thermal blankets covering almost all areas of the spacecraft except for the radioisotype thermoelectric generators (RTGs, i.e., the nuclear power source for Galileo; it will fly too far from the Sun to be able to use solar panels), radio antennae and selected radiating areas.

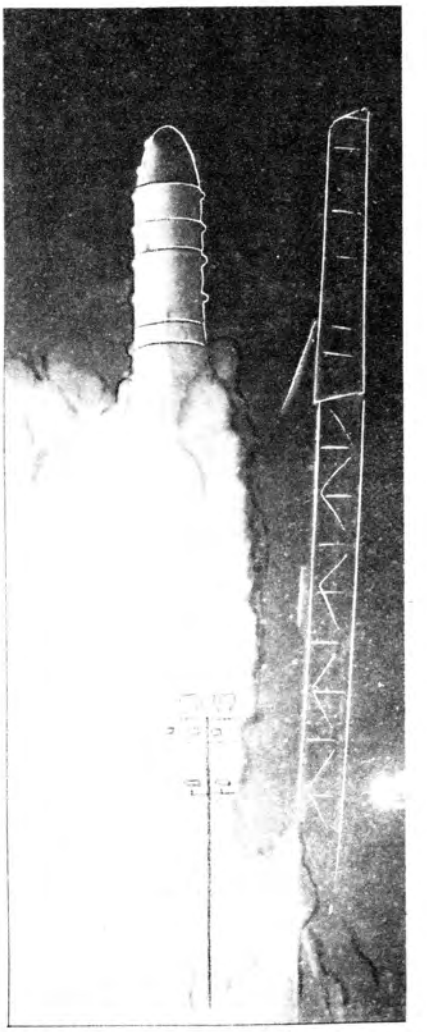
TEST YOUR SPACE KNOWLEDGE

The short space quiz in May's issue proved to be so popular that a second set of questions to test your astronautics brains is included this month. Many of them are based on material from Spaceflight *over the past couple of volumes, others require some digging into the dim recesses of your space knowledge. There are no prizes but if you score 100% then you really must be a space genius! Answers are on p. 336.*

1. Whose autobiography is "Return to Earth"?
2. Name the five known moons of Uranus.
3. Who discovered the two known moons of Mars?
4. Who was the only scientist to walk on the Moon?
5. Who launches "N" rockets?
6. What was OSO?
7. Name the holders of the space endurance record.
8. What is the approximate Shuttle launch weight?
9. Who flew the second Shuttle orbital mission?
10. What is the name of the ESA Mars orbiter under study?
11. What is VRM?
12. Which planet has "spokes"?
13. What was the first man-made object to strike the Moon?
14. Which probe was the first to return pictures from the lunar surface?
15. Which was the first man-made satellite of the Moon?
16. What was the first man-made object on Mars?
17. Whose callsign was "Seagull"?
18. Who was the first human to spend more than a day in space?
19. Which satellite discovered the Earth's Van Allen radiation belts?
20. What is IRAS?
21. How did Einstein get into space?
22. Where would you find the *Spirit of St. Louis*, *Columbia*, the Wright Flyer and *Friendship 7* all together?
23. When and what was the first 3-man space mission?
24. What is Palapa?
25. What is Galaxy?



Picture 2: which Apollo mission is this?

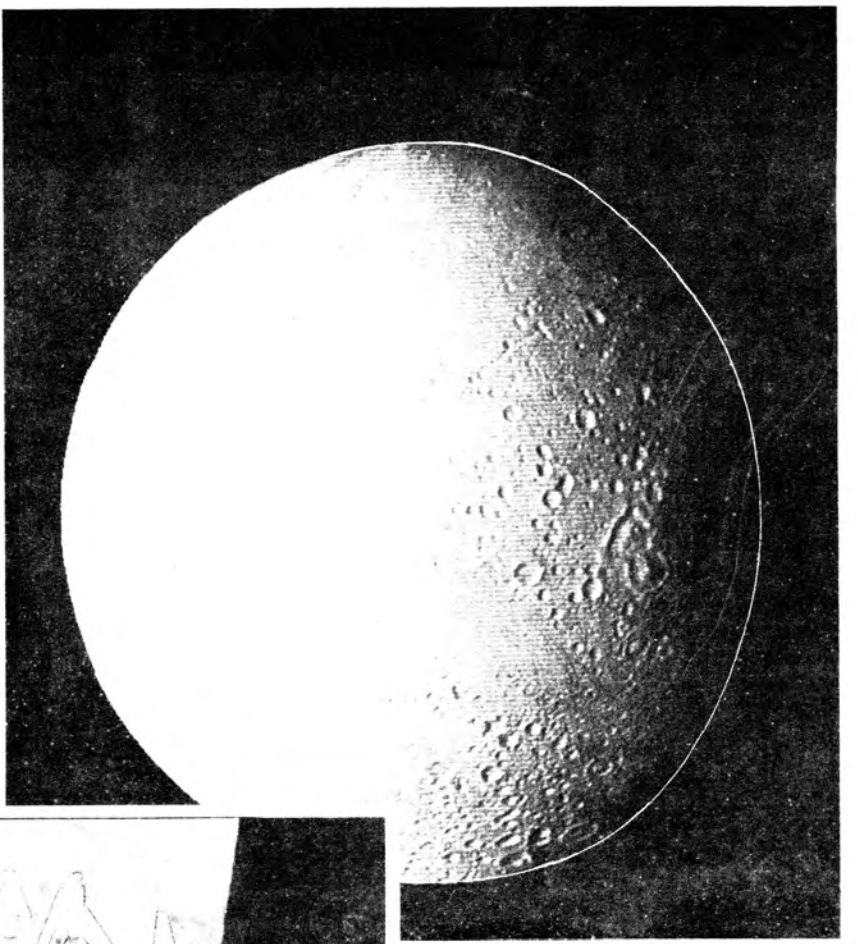


Picture 1: what rocket is this?

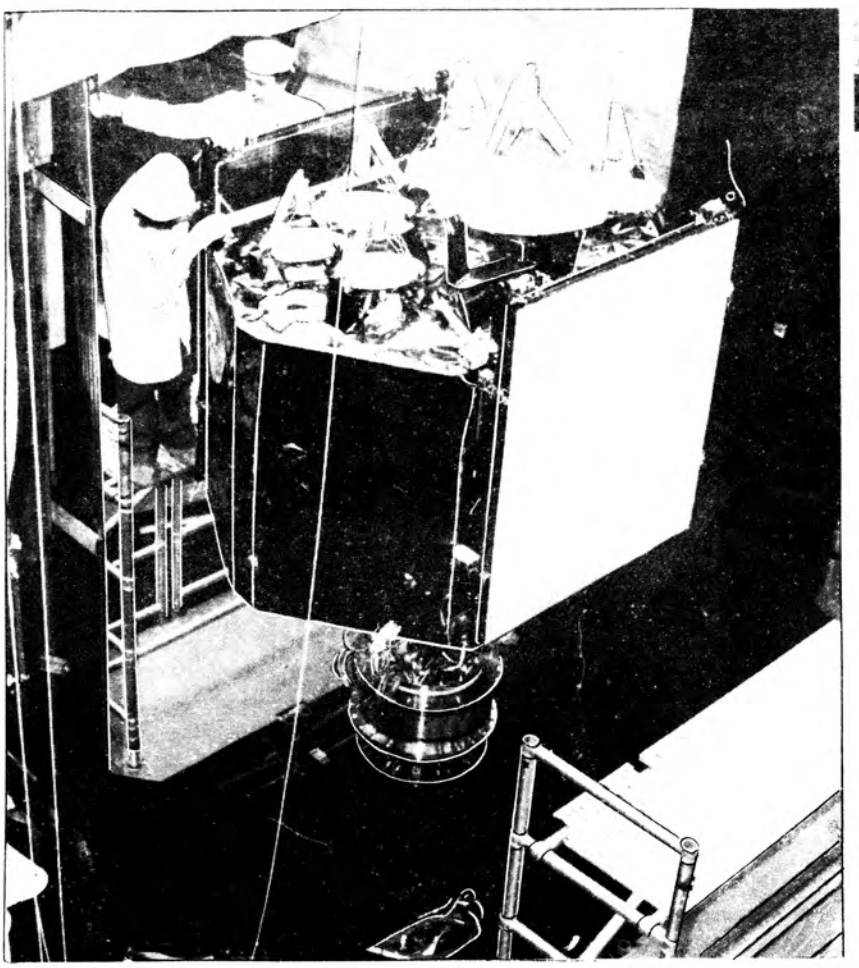
26. What is LDEF?
27. (i) Who was the first BIS President?
    (ii) Who is the present BIS President?
28. Name the second woman in space.
29. (i) What is the most distant known object in the Universe?
    (ii) How far is it (in light years)?
30. Where is the Tom Mutch Memorial Station?
31. Who made the first Shuttle space walks?
32. What is TOPEX?
33. What would the period of a satellite be just above the Moon (mins)?
    (a) 90; (b) 100; (c) 110.
34. (i) What is the Earth surface escape velocity (km/s)?
    (a) 8.1; (b) 9.8; (c) 11.1.
    (ii) What is the Sun's surface escape velocity (km/s)?
    (a) 170; (b) 620; (c) 940.
35. Who said "I do not believe that this generation of Americans is

willing to resign itself to going to bed each night by the light of the Communist Moon"?

36. What was the first major rocket launched from Cape Canaveral?
37. What was the first recovered man-made object from space?
38. Which manned Mercury capsule was lost?
39. Who was the first man to fly around the Moon on two separate occasions?
40. Which Salyut space station is currently in orbit?
41. Name, in date order, the nations who have launched their own satellites.
42. Which of the Moonwalkers was also an X-15 pilot?
43. Who was the first man to go into space three times?
44. Which satellite returned the first pictures of Earth from orbit?
45. Who is the Director-General of ESA?
46. Which unmanned craft brought back samples of the Moon?
47. Who is the NASA Administrator?
48. Which planets do not possess moons?
49. What is ISPM?



Picture 3: which moon is this?



Picture 4: what satellite is this?

50. How many engines does the Ariane first stage carry?
51. Who plans to build the Tele-X communications satellite?
52. Name the first French cosmonaut.
53. Who discovered Saturn's rings?
54. Name the two moons of Neptune.

55. What have Ariane's engines, a Swedish satellite and a US sounding rocket of the 1950's in common?
56. Which of the outer planets are not yet known to possess rings?
57. What is Starprobe?
58. Where would you find:
    (i) Tsiolkovsky.
    (ii) Atalanta Planitia.
    (iii) Caloris.
    (iv) Olympus Moons.
59. What is Planet A?
60. What is special about Kosmos 1383?

NEW SATELLITE PROPOSALS

NASA's Lewis Research Center has asked for proposals for the design, development, building and launch of the Advanced Communications Technology Satellite (ACTS), with a view to awarding the contract in December.

The Advanced Communications Technology Satellite is scheduled for launch by the Space Shuttle in 1988 and would be used for communications experiments for two years. Technologies to be developed include:

- A new multibeam antenna on the satellite for communicating with *small* areas on Earth of about 240 km in diameter (spot beams). This service would allow the frequency bands to be reused, increasing the system's capacity many times. Today's satellites typically cover areas as large as the entire United States or Europe.
- An on-board computer that receives signals from ground stations, sorts, groups and stores them temporarily in its memory banks according to their destinations and schedules their transmission to the appropriate ground terminals at the proper time and on the appropriate spot beam.
- An on-board switch that will route high data rate message traffic over fixed spot beams to major communication centres.

According to the proposal, commercial space communications systems to be introduced in the 1990's will require technological advances to allow the crowded skies and frequencies to be used more efficiently.

INTELSAT BUSINESS SERVICES

Intelsat is to go ahead with modifications to two of its satellites to provide digital international business communications services. The Board of Governors agreed in March to modify the last two satellites in the Intelsat VA series (F-14 and F-15) for business operations at a cost of $23.8 million plus orbital incentives.

"Business services" includes international video conferencing, audio conferencing, digitally-compressed voice services, electronic mail, store and forward voice mail, high speed facsimile and interactive computer networking.

While a form of business services using existing satellites at 14/11 GHz frequencies might be available earlier, the modified satellites could cover the Atlantic Ocean area from as early as 1985. Services in the Indian and Pacific Oceans are planned to start soon after. They will be able to operate in either the 14/11 or 14/12 GHz frequency bands, and will be located at either 323°/329°E longitude or 307°/310°E longitude.

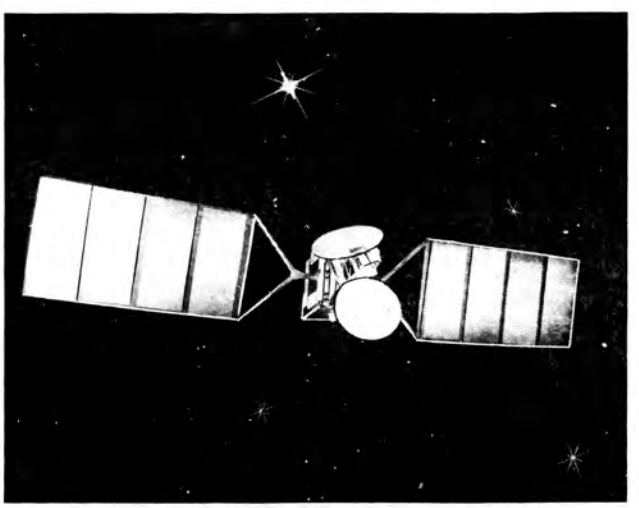
Intelsat is continuing to study further business augmentation by the following means:

- Modifications to the last two of the five very high capacity Intelsat VI satellites now on order;
- Possible lease of capacity on the United Kingdom's Unisat satellites.

SPREADING THE WORD

The first commercial satellite communications link with the Federated States of Micronesia (FSM) was inaugurated in March. A 13 m station on the island of Ponape, southwest of Hawaii in the eastern Caroline Islands, now provides a full range of satellite services, including voice, telex, data and television. Initial services are *via* a Pacific Intelsat satellite to Hawaii through the Comsat-operated Earth station at Paumalu on the island of Oahu, interconnecting to the Hawaiian Telephone Company.

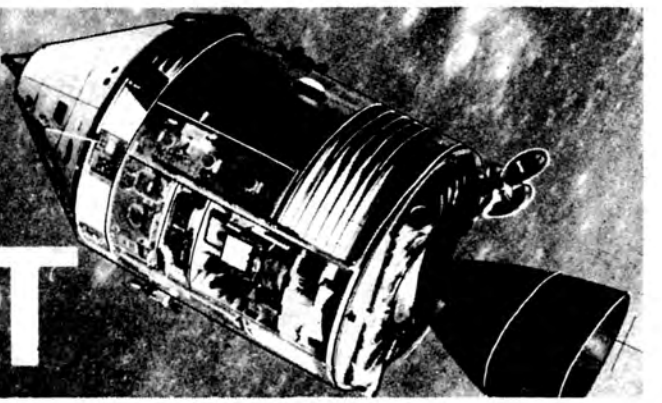
Dr. John McLucas of Comsat World Systems Division said, "This satellite facility places Ponape in the mainstream of worldwide communications overnight. The antiquated and often unreliable high frequency radio system soon will only be a memory. Instantaneous telephone calls to nearly any point of the globe will be fractions of a second away.



TDF-1 (France) and TV-SAT (W. Germany) are being built in a joint project for launch in 1985 to provide direct TV services to those countries. Each will provide 3 TV channels for viewers with 90 cm dish antennae.

Aerospatiale

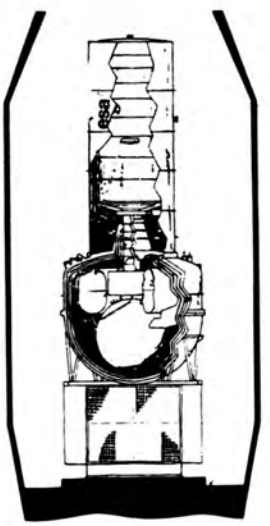
SPACE REPORT



NEW ESA SATELLITE

On 29-30 March 1983, ESA's Science Programme Committee agreed to the Director General's proposal to undertake a new scientific project in infrared astronomy. The satellite for the early 1990's, called ISO (Infrared Space Observatory), will allow observations in the infrared wavelength region with an unprecedented sensitivity.

ISO consists essentially of a 60 cm diameter telescope and instrumentation sensitive to infrared radiation (1 to about 200 microns). In order to reduce the background signals from the telescope and to provide the working temperature for the infrared detctors, they are cooled to cryogenic temperatures (about −260°C) by liquid helium and liquid hydrogen. ISO should have an operational lifetime of at least 18 months, and should survey the whole sky a number of times.



A 1980 concept of ISO inside its Ariane launch shroud. The telescope itself is the cylindrical section at top; the cryogenic liquids are carried in the tanks below.

ESA

Of the many areas on which ISO will have an important impact that of extragalactic astronomy is expected to be to the fore. Detailed observations of selected galaxies, especially involving spectroscopy of the nearer and brighter ones, will produce much valuable new information. With those galaxies containing large amounts of dust, the infared measurements can probe into regions that are completely obscured from visible observation. Extending observations out to the most distant galaxies might enable a new distance scale for the Universe to be established. In this respect, the measurements of ISO will complement the studies being undertaken from the Space Telescope in the visible range.

Star formation occurs inside large clouds of gas and dust, hidden from normal view. ISO will be able to probe into these regions and allow this process to be studied in detail. Spectroscopic analysis of the infrared radiation emitted by various regions throughout our own Galaxy and in other nearby galaxies will provide a better understanding of the chemical and dynamical evolution of these objects. Within the Solar System, studies of the giant planets, asteroids and comets will benefit enormously from the high sensitivity of ISO and the range of measurements with the infrared instruments.

The development of ISO to provide this detailed information is now very timely, following the successful launch of the IRAS satellite last January. With the production of the sky survey maps from IRAS at a number of infrared wavelengths, an excellent basis will be established for a further detailed investigation with ISO.

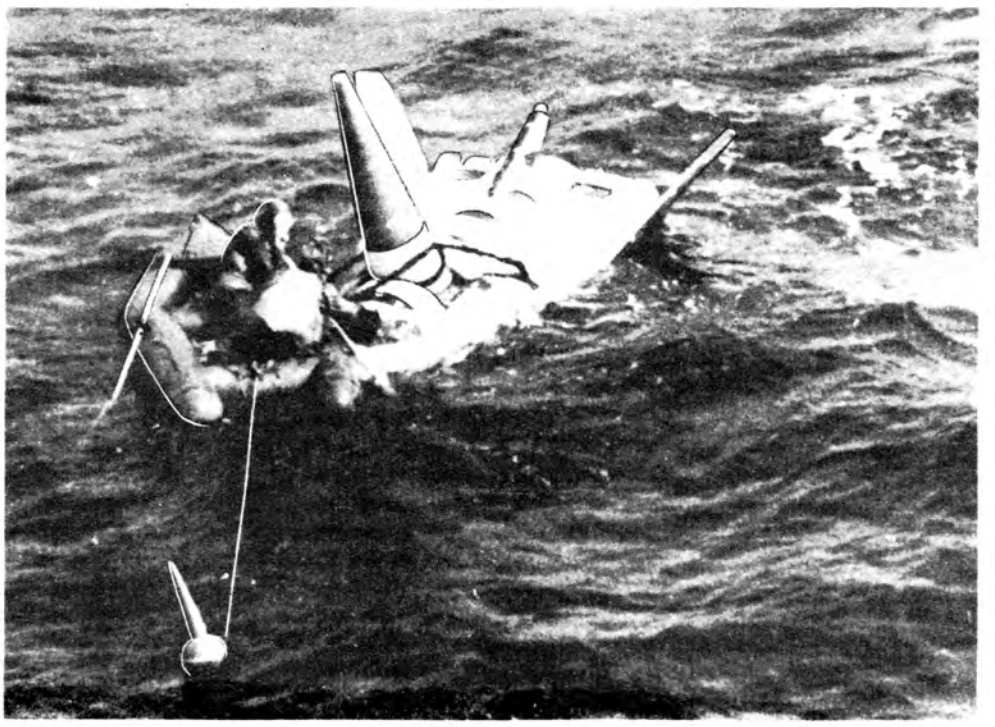
SHUTTLE CREWS NAMED

Parts of three new Shuttle mission crews were named by NASA in February, two of them for Spacelab flights.

STS-13, due to repair the ailing SMM solar observatory in April 1984, will be commanded by Bob Crippen, already assigned to STS-7 this summer and veteran of the first Shuttle mission two years ago. This new assignment will make him the first man to fly the reusable craft three times. His new crew are Frances Scobee (pilot) and mission specialists George Nelson, Terry Hart and James van Hoften. Nelson will fly a Manned Maneuvering Unit to capture SMM for on-the-spot repairs.

Spacelab 3 will fly aboard STS-18 carrying materials processing, space technology and life sciences experiments. The commander will be Bob Overmyer with pilot Fred Gregory and mission specialists Don Lind, Norman Thagard and Bill Thornton. Overmyer flew as STS-5 pilot in November 1982, and Thagard and Thornton will also fly STS-7 and -8, respectively.

STS-24 will take aloft Spacelab 2 with mission specialists Anthony England and Karl Henize to carry out astronomy and physics observations. Spacelab 2



Public confirmation that the Soviets are testing models of winged re-entry vehicles, apparently as a precursor to manned shuttle flights, came with the dramatic Kosmos 1445 photographs taken by the Royal Australian Air Force on 16 March 560 km south of the Cocos Islands. The 1000 kg model was recovered after launch from Kapustin Yar and 1½ circuits of the world. The upper surface features two upturned wingtips and small vertical tail, somewhat similar to US lifting bodies of the 1960's. The large cone appears to be part of the recovery system.

Courtesy of the Australian High Commission London

had to move to a later launch slot because of delays in completing the Instrument Pointing System necessary for the flight.

Payload specialists and the STS-24 pilots will be named later.

It is possible that a payload specialist from the McDonnell-Douglas company will fly on the STS-12 mission to run the electrophoresis biological unit. The main mission objective is to orbit the third TDRSS communications satellite as a backup to those launched by STS-6 and STS-8.

A LARGER SUN?

Scientists flying through the Moon's shadow during a total eclipse have discovered that the Sun might be bigger than it looks.

New infrared measurements were made from NASA's Kuiper Airborne Observatory, a jet equipped with a large infrared telescope, flying 13 km high over the Pacific Ocean on 31 July 1981. The scientists found that the Sun's diameter viewed in infrared light is significantly greater than in visible light.

Almost all of the infrared radiation comes from the chromosphere, a hot thin layer of gas lying several thousand kilometres above the surface.

Scientists believe these new measurements show regions of dense material extending higher into the chromosphere than previously realised.

This was the first time that KAO had been used to observe the Sun. Most infrared radiation from astronomical sources is absorbed by water vapour in the Earth's atmosphere, but KAO can climb into the stratosphere to observe infrared light. Precise navigation was required to intercept the Moon's shadow as it swept across the Earth's surface at over 6,000 km per hour.

The Moon's sharp edge, as it eclipsed the edge of the Sun, was used to pinpoint the Sun's infrared edge, allowing much greater accuracy than expected from ordinary ground-based telescopes. The continued detection of infrared radiation several seconds after all visible light shows that the infrared edge extends more than 2,000 km beyond the visible limit.

METALLURGICAL RESEARCH

NASA and GTI Corp. have decided not to continue past Phase One of a year-old Joint Endeavor Agreement on low-gravity metallurgical research experiments in space.

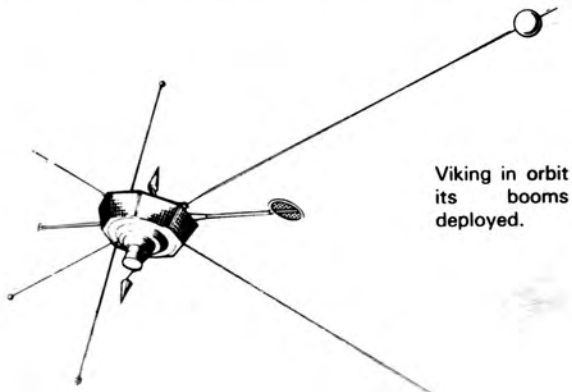
The JEA was signed on 20 January 1982, the first of its kind between NASA and a non-aerospace company. During Phase One, GTI investigated the technical and commercial feasibility of renting facilities for low-gravity metal alloy resolidification experiments aboard the Space Shuttle. GTI concluded that there is, currently, not a sufficient customer market to support a viable commercial enterprise. Flights were intended to begin aboard the Shuttle next year.

NUCLEAR POWER SYSTEMS

A US project to assess the requirements for space nuclear reactor power systems for possible use in future civil and military space missions has been set up.

The "SP-100" research programme will look at: thermo-electric and other power conversion technologies; high-temperature metals and materials; radiator structures for removing waste heat in space; and high-temperature nuclear fuels. Even at this early stage, a primary goal will be to ensure that safety aspects are fully considered.

A potential result is a space nuclear system in the 100 kW range at lower weights, sizes and costs than even the most advanced solar energy systems could provide. Such nuclear systems are highly desirable for NASA's advanced, deep-space missions, and could lead to entirely new classes of communications and other satellites. An additional advantage for military missions is that satellites with nuclear power sources could be far less vulnerable to attack in space.



Viking in orbit with its booms deployed.

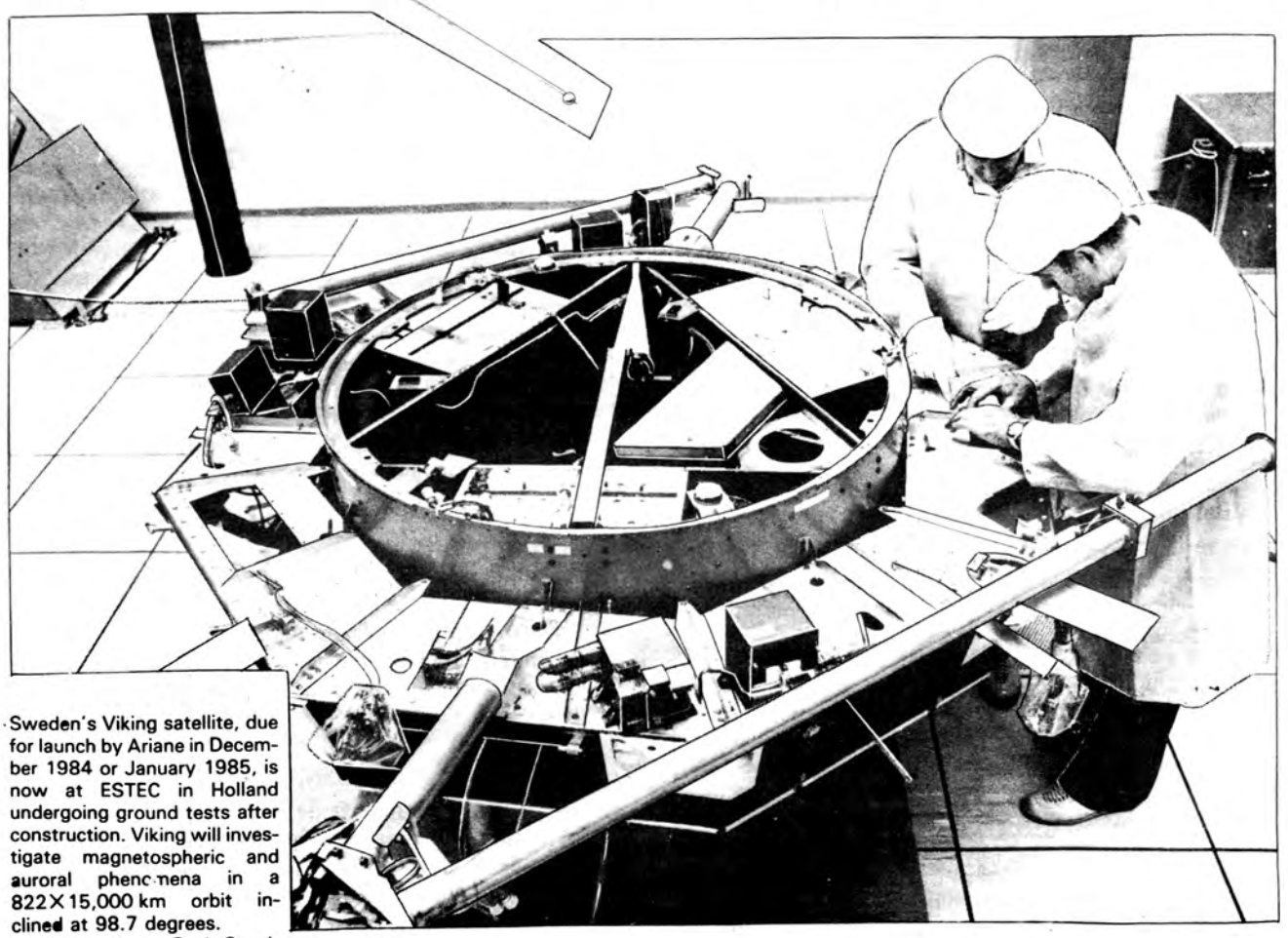
PRIMORDIAL CLOUD

Dr. Yervant Terrizan of Cornell University has discovered a unique hydrogen cloud in space, writes Gerald Borrowman.

Dr. Terrizan says, "The universe is composed of many galaxies, each one containing billions of stars. But (previously) we had seen almost nothing in the space between galaxies within this huge vacuum. For the first time we have found a huge mass of hydrogen gas in the space between galaxies.

"The cloud is at least as three times as big as our Milky Way galaxy and it contains about an equal amount of mass. It is something like a hundred-billion [i.e. 10^{11}] times the mass of the Sun."

Dr. Terrizan went on to explain that while there is material between stars within galaxies the density of material between galaxies is extremely low. He says, "We find that the cloud is rotating. And in order for it to stick together it has to have a very large amount of other invisible matter. This is probably a primordial cloud from the very beginning of the universe in the Big Bang. Most probably it is a proto-galaxy that didn't quite mature. There may be other clouds out there waiting to be discovered. If this is the case then the total mass of the universe is much more than what we thought and it is possible that this material may contribute to the gravitational forces to pull the universe back to where it started. So it has implications for our cosmological theories."



Sweden's Viking satellite, due for launch by Ariane in December 1984 or January 1985, is now at ESTEC in Holland undergoing ground tests after construction. Viking will investigate magnetospheric and auroral phenomena in a 822×15,000 km orbit inclined at 98.7 degrees.
Saab-Scania

NEW SHUTTLE PROTECTION

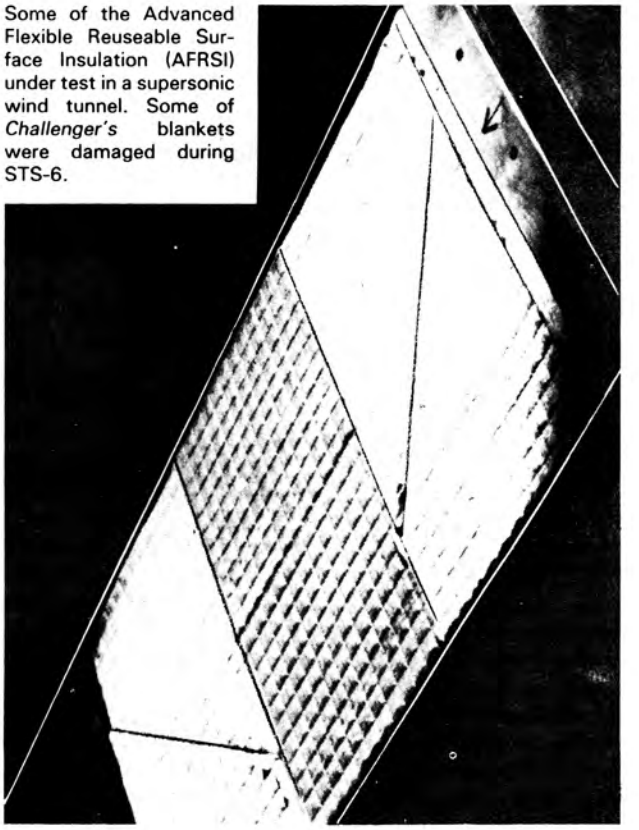
NASA is continuing to test a new thermal-protection material, already used on Shuttle *Challenger* in small amounts, for subsequent application to the other Orbiters.

Flown aboard a NASA Dryden F-104 research aircraft, the insulation, called Advanced Flexible Reusable Surface Insulation (AFRSI), is a new material that uses several forms of silica fabricated in sheets about 1 m square.

Adhesively bonded to the aluminium skin of the Orbiter, AFRSI protects it from the extreme heat experienced in re-entering the Earth's atmosphere in much the same way as the tiles found on other portions of the Orbiter. Because it is lighter, cheaper and easier to apply, the AFRSI will eventually replace most of the white tiles used on *Columbia*, as well as some of its Nomex felt (FRSI). On *Challenger*, the AFRSI will be used on the Orbital Maneuvering System pods, while on the Orbiters *Discovery* and *Atlantis* it replaces FRSI and most white tiles.

For these tests, the material is mounted on a frame which is then fitted to a specially instrumented flight test fixture mounted beneath the belly of the F-104.

Flying a profile precisely maintained with the help of ground computers, the pilot subjects the AFRSI to air loads that are equivalent to those that are experienced in actual Space Shuttle flights.



Some of the Advanced Flexible Reuseable Surface Insulation (AFRSI) under test in a supersonic wind tunnel. Some of *Challenger's* blankets were damaged during STS-6.

A UNIQUE SOUVENIR

In response to many demands, glass tankards of the type presented to the Speakers at Space '82 are being made available to members in a limited edition of 100. Orders (UK only – sorry but we can't run the risk of damage in sending abroad) should be *sent direct* (not to the Society) to:

Western Glass International, Western Glass Works Ltd., Armstrong Rd, Daneshill East, Basingstoke, Hants RG24 0QE.

The cost is £10 (postage & packing free). All profits will be donated to the Society so this is your chance to obtain a unique souvenir and to benefit the Society at the same time.

GET TIED TO OUR 50th ANNIVERSARY

ANNIVERSARY TIES

Why not show everyone that you belong to one of the world's oldest space organizations by wearing its new 50th Anniversary tie? We have always produced a high-quality navy blue tie that will grace any space buff's apparel. Now, to mark our 50th year, we are re-introducing the former blue tie showing a rocket against a star background.

For our 50th Anniversary year, the rockets will appear in GOLD to show, unmistakeably, that we have every reason to be proud of our achievements.

As these ties will be unique souvenirs only a limited number will be produced, so please place your order now to avoid disappointment. Next year, the ties will revert to the silver motif once more.

Orders, with a remittance of £6 UK or £6.50 ($13) abroad for each tie required, should be sent to: The Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England.

JAPAN'S NEW ROCKET ENGINE

By Neil W. Davis

This third article in a series (the first two, "Japan: First with DBS" and "Japan's Halley's Comet Probes," were published in the May and June issues, respectively) looking at space developments in Japan covers an important new addition to far-eastern rocket technology: the cryogenic engine.

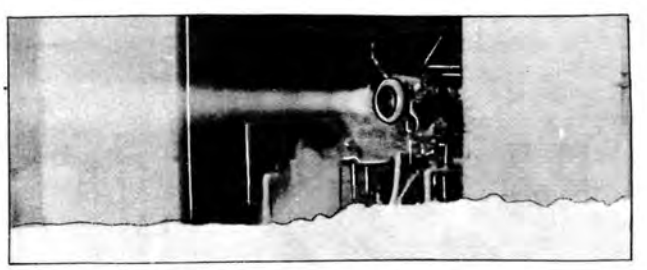
Introduction

Japan's three major rocketry groups and the domestic space companies are developing two cryogenic engines for use starting from about 1986. The National Space Development Agency (NASDA) plans to use the LE-5 liquid oxygen/liquid hydrogen engine in the second stage of its next-generation launcher, the H-1A. The current NASDA "N-2" launcher uses the AJ10-118FJ, a Japanese-improved version of the Aerojet Delta second-stage engine.

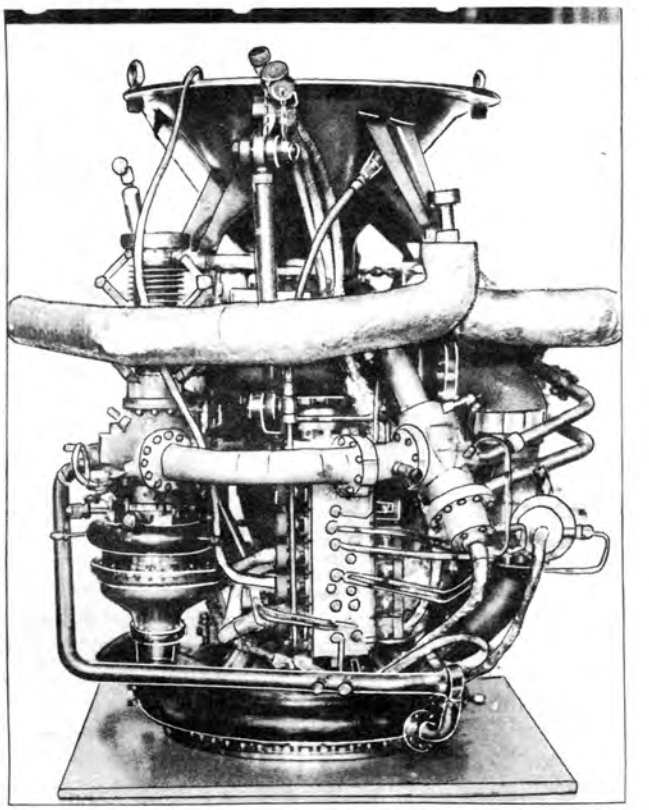
As an agency of Japan's Ministry of Science and Technology, NASDA is striving to produce its own, domestic, space technology. This LE-5 project, along with an inertial guidance system and a three-axis control system for satellites, is among the current "targeted" projects. The Institute of Space and Astronautical Science (ISAS) is both contributing to the NASDA project and developing its own cryogenic engine with a unique turbopump.

ISAS, which launches scientific satellites using solid propellant rockets made by Nissan Motors, has been developing its LOX/LH_2 rocket engines since the mid-1970's. In 1972, Professor M. Nagatomo suggested that they should begin studies toward developing a cryogenic engine for the ISAS Mu rocket series and subsequent launch vehicles. NASDA, as the applications satellite group, presently uses US Delta rocket technology in order to accelerate its launcher development schedule, but its rocket group is striving to produce a fully Japanese cryogenic engine to end its reliance upon foreign technology in sophisticated hardware.

In October 1982, NASDA completed a series of preliminary simulated high altitude tests with the LE-5 at the Kakuda Prpulsion Test Center in Miyagi Prefecture (in nothern Japan on the Pacific Ocean). The first inflight test is scheduled for 1986 as part of the H-1A's "Engineering Test Vehicle-II" (without a third stage). This ETV-II will orbit an "Experimental Geodetic Payload" reflecting satellite for a laser geodetic triangulation project.



Test firing the LE-5 prototype.



Prototype version of the LE-5 with the nozzle at top.

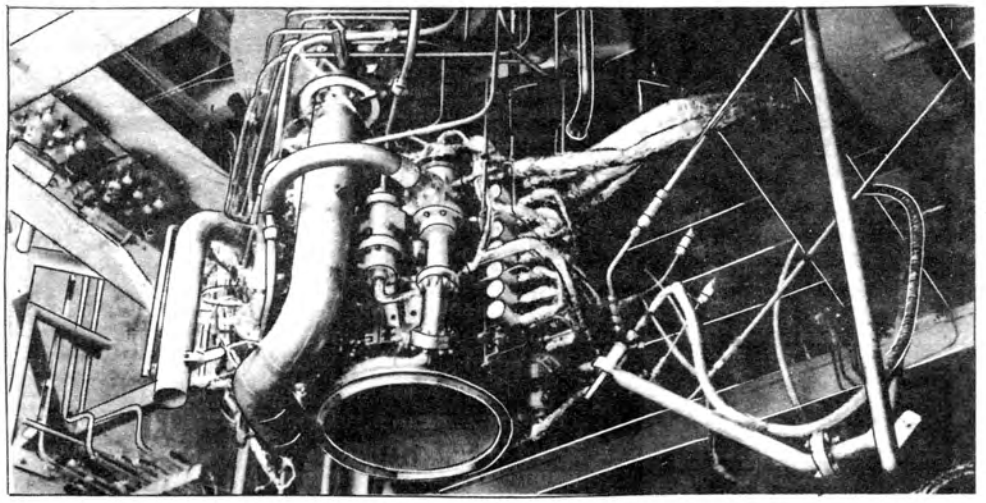
NASDA

The LE-5 manufacturing work is being done by Mitsubishi Heavy Industries, the largest rocketry company in the nation. Some other systems, such as the turbo-pump, are being manufactured by Ishikawajima-Harima Heavy Industries (IHI). These two companies are the main builders of the three-stage H-1A, which will be capable of the geostationary orbital injection of a 550 kg satellite.

The 255 kg (dry weight) LE-5 develops 10.5 tonnes of thrust (vacuum). The specific impulse is 447 seconds, with the combustion pressure about 37 times atmospheric.

A non-standard feature is the simplified start-up system which avoids the need for a solid starter. The combustion chamber is built up of 240 steel tubes; the nozzle extension consists of 650. The engine will be re-startable so as to inject satellites into polar orbits.

In January 1982 a preliminary design review was finished and the LE-5 given the go-ahead. Thirteen engines will be used in an extensive testing period stretching into 1985. By early 1984, the critical design review should be completed; a post qualification test review is scheduled to be completed in 1985.



A test model of the ISAS 7 tonne-thrust cryogenic engine at the Noshiro test centre.

ISAS

The ISAS Engine

In the mid-1970's, ISAS started developing a 7 tonne thrust second stage cryogenic engine, but this was soon upgraded to match the NASDA 10 tonne specifications. The ISAS engine was originally to be used in the Mu-series of launchers, but there is presently some doubt about this plan, according to Professor Tanatsugu.

This engine features a unique turbopump which places the liquid hydrogen and liquid oxygen pumps at either end of a single housing. Tests with a small model of the channel wall thrust chamber were completed in the late-1970's. The 7 tonne engine has a 433 second specific impulse (vacuum) and a chamber pressure of 25 times atmospheric.

ISAS began the design of the 10 tonne engine under the orders of the Space Activities Commission (SAC), the highest space administrative body in Japan. Both were completed and tested in 1981.

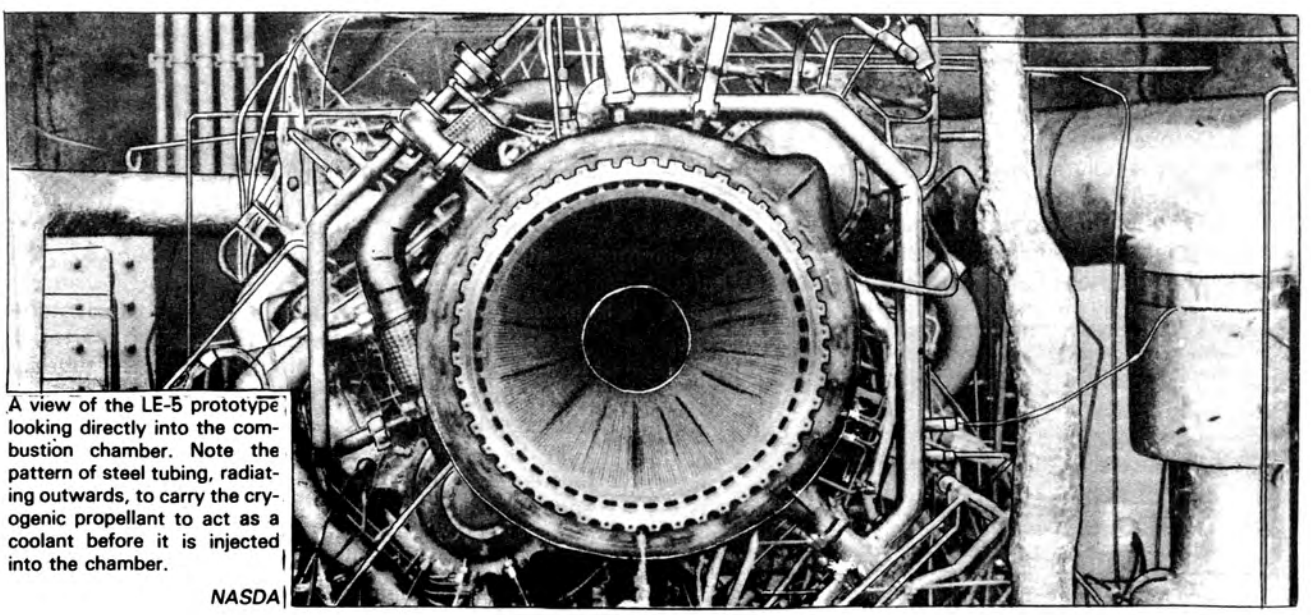
Professor Nagatomo, who originated the ISAS cryogenic engine project, has plans for larger and more advanced cryogenic engines. Although Dr. Yasuhiro Kuroda retired from NASDA in 1981, his team is carrying out the main Japanese LOX/LH_2 engine development. NASDA originally aimed for a 10 tonne thrust engine but Mr. E. Sogame of their rocketry group reports that performance exceeds expectations. They are trying to reduce the engine's weight, which also exceeded expectation.

The Future

A launch vehicle beyond the H-1B (800 kg to geostationary orbit) on the drawing boards may be used in the 1990's to orbit a Japanese "mini-shuttle." Japan will have to move into its second phase of advanced cryogenic engine development to make it possible. It is likely that Professor Nagatomo, who will drop-test a small shuttle model within the next few years, will be one of the central figures.

Acknowledgement

I would like to thank Profs. N. Tanatsugu and M. Nagatomo of ISAS; Mr. A. Kubozono and Mr. E. Sogame of NASDA; and Dr. Y. Kuroda (NASDA retired).



A view of the LE-5 prototype looking directly into the combustion chamber. Note the pattern of steel tubing, radiating outwards, to carry the cryogenic propellant to act as a coolant before it is injected into the chamber.

NASDA

THE 1950's – A PIVOTAL DECADE

Adrian Perkins*

For those in school now, the nineteen fifties is history. It was a key decade for the development of Space. Science fiction – in Space Travel, at least – travelled hand-in-hand with science fact for a while. Space fantasy and serious scientific speculation were closer than they have been since, or likely to be again, and looking back, it is often impossible to differentiate them. The media was being used, often knowingly, by engineers and scientists to make the public aware of their activities. It was an *education* period important to space history. What follows is an examination of that time. It is not meant to be exhaustive – it considers only Western sources for example – but tries rather to give a "flavour" of what was happening in key areas in the USA and UK. It can be considered a part-history of an exciting technology, or an illustration of how an idea can take root in the public's imagination.

Vehicle Shapes

Science fiction placed the spacemen of the 1950's in vehicles very much like those then being designed and built for high-altitude aeronautics and space projects. They tended to be sleek and aggressive. The rockets of that time owed much to the early 1930's experiments in rocketry conducted by the Berlin-based German Rocket Society (VfR). Started as a group of enthusiasts their work had been progressively taken over by the German army and led by 1942 to the single stage German Army missile, the A4 – or as Nazi propaganda called it "the Vengeance Weapon 2" or V2.

One of the early 1930's enthusiasts was a 20-year old PhD engineering student, Wernher von Braun. He contributed considerable "know-how" to the VfR projects and, after a certain amount of persuasion, became attached to the German Army at their fledgling Rocket Development Centre. Under the leadership of Walter Dornberger it was Dr. von Braun and his engineering team who perfected the A4.

Wernher von Braun was in many ways a prime motivator of the conquest of Space and played a major role in many of the media presentations of the 1950's. His interrogation report, publically read in London in 1946, showed not just the progress achieved by the German team at their Peenemünde site but also that the Centre's scientists had kept alive the space flight ideal despite the pressures of the military establishment.

In order to improve the range of the V2, test rockets had been fitted with swept-back wings to see if they would glide in the upper atmosphere. One such winged-V2 vehicle had flown with some degree of success in 1944, and drawings existed for a three stage version in which a pressure cabin replaced the warhead so that a man could fly in space.

After the war members of the Peenemünde team regrouped under the auspices of the US Army Air Force at the White Sands Artillery Proving Ground in New Mexico. They began working again with captured V2 rockets. Some 70 were fired in various modified and unmodified forms. Several years later the U.S. Army's Guided Missile Development Group moved to Huntsville, Alabama, and Wernher von Braun became Technical Director.

Wernher von Braun.

Keystone Press Agency

As the captured A4's successfully proved the technology for what had only been theoretical principals before, Wernher von Braun developed, via writings and drawings, the basic flight plan for the uses of rocketry in space.

In the decade after WWII, there were numerous proposals for streamlined winged rockets and spacecraft for both orbital and sub-orbital flights. 1949 saw the publication in the United States of an illustrated text which is now seen as a milestone in the history of astronautics. The book was written by a science journalist specialising in rocketry, Willy Ley; by then a naturalised American, he had been German by birth and, in the late nineteen twenties, one of the founders

* Based on material presented in his talk "Man's Journey Into Space: 1950's Style" at the Society HQ 11 March 1982.

of the VfR. The book was illustrated in near-photographic style by architectural visualiser and illustrator, Chesley Bonestell.

The book's title was "*The Conquest of Space*"; that "Conquest" involved a single-stage streamlined manned lunar landing craft. Chesley Bonestell's typical combination of aesthetic beauty and technical knowledge is nowhere better seen than in his designs for this book – subtitled "*the greatest adventure awaiting mankind*". The illustrations of what might be observed from this craft in flight above the Earth and the Moon were spectacular. At a time when the only high-altitude photos the public normally saw were from A4 rockets, the book offered a vision to spark the imagination.

Another source of inspiration for fictional vehicle shapes at the time was the advanced experimental aircraft then being flown. In Britain it was delta-winged jets, in the US the craft made for the newly-created U.S. Air Force, and the U.S. Navy, flying from a dry lake airfield in California called Muroc Field (since 1950, renamed Edwards Air Force Base). Most of the experimental aircraft there were strangely-shaped jet engined craft, but there was also a new breed, the rocket planes.

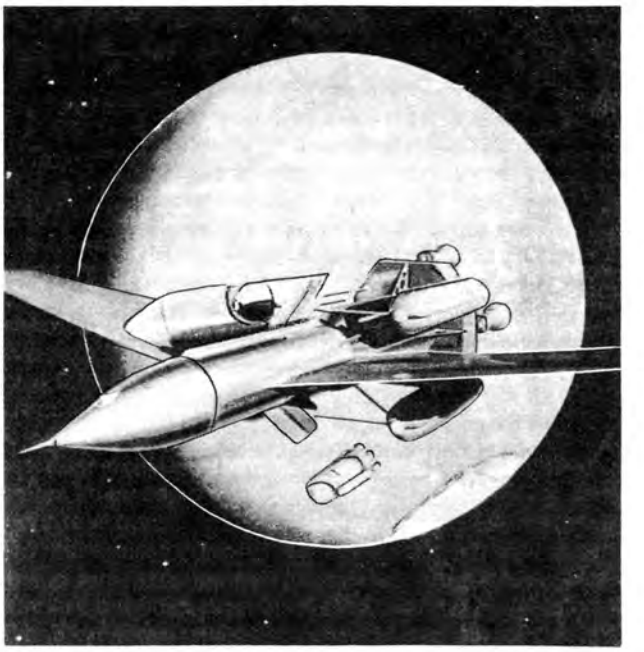
They were unique in that they had to be transported to high altitude by a specially modified carrier aircraft, not piggyback as we see today for the Orbiter/747 composite, but under a wing or fuselage. In October 1947, U.S. Army-Air Force aviator Capt. Chuck Yeager was the first man to break the sound barrier, using the first of the rocket planes, the Bell X-1. The Air Force followed it with the record breakers X-2 and X-3. The Navy meanwhile flew the slender Douglas Skyrocket. In 1950 naval aviation ceased at Edwards, and was replaced by the mainly-civilian operated National Advisory Committee for Aeronautics (NACA), who dropped the Skyrocket.

The Air Force X-2, and X-3, led on, however, by the late '50s to the X-15, a true space plane. NACA became NASA (National Aeronautics & Space Administration) in 1958, and all astronautics became the province of NASA in 1960. The Air Force's projects with rocket planes ended but it used the knowledge it had gained in designing the jet powered, delta-winged, trisonic Lockheed SR-71 we know today. NASA took over the X-15, flying it to a height of 59.6 miles (95.3 km) in 1963. By then its rocket engine was delivering almost as much thrust as the Redstone rockets that lobbed the first manned Project Mercury capsules out over the Atlantic.

By the end of the '50s, literature on Flight in Space had become more and more technical in line with the wealth of data flowing back from the experimental aircraft flights. Speculation turned to technology.

Colliers

During the early 1950's the American military embarked upon a series of inter-service and public meetings on certain aspects of defence. One, held at San Antonio, Texas, was on the speculative aspects of high-altitude and space applications. Talking there were the experts in the field, including von Braun from the U.S. Army's Redstone Arsenal. Gordon Manning, the Editorial Managing Director of the weekly Collier's



"The Mars Expedition, 8600 miles from its goal" by Chesley Bonestell (1954), published in *Colliers* magazine.

© Chesley Bonestell

magazine – an East Coast mass circulation periodical stylistically similar to "*Life*" or "*The Saturday Evening Post*" – had contacted Willy Ley and Chesley Bonestell shortly after publication of "The Conquest of Space" to discover whether they had encountered any academics or specialists who were working on anything similar. Together with the Associate Editor of Collier's magazine, Cornelius Ryan, Chesley Bonestell attended the San Antonio meeting.

They met von Braun, and shortly afterwards a decision was taken to prepare the groundwork for a series of articles on Space Travel. Later it was decided to organise a conference in New York. This meeting, which was to become the first in an annual series, was held on the 12th October 1951 at the Hayden Planetarium. The lectures were used to provide the framework for the magazine's series on a full scale space programme. This space programme outlined manned reusable vehicles to Earth orbit, a space station, a lunar reconnaissance journey and finally a landing on the Moon by a fleet of space ships.

The Symposium was organised by Willy Ley – the science fact writer whose book "*Rockets, Missiles and Space Travel*" was the then-standard text on astronautics. The lecturing team assembled was dedicated to exploring the possibility – in unprecedented detail – of space travel. Their only purpose was to produce a viable plan for going to the Moon and back. This team included Dr. Wernher von Braun, Dr. Fred L. Whipple (astronomer), Dr. Joseph Kaplan (physicist), Dr. Heinz Haber (aviation medicine specialist), Willy Ley and Oscar Schachter (a U.N. authority on International Law).

Collier's magazine published the Spaceflight Symposium lectures – extensively revised – and profusely illustrated by Chesley Bonestell, Rolf Klep and Fred

Freeman. The series began publication in March 1952, the occasional articles spanning some three years.

Prior to publication scale models were built of much of the hardware. A shuttle would transport 10 men and 36 tons (36,000 kg) of cargo into a 1,075 mile (1,720 km) high polar orbit. Standing 265 feet (79.5 m) high at launch, it was to have common propellants nitric acid and hydrazine in all three stages. After completing orbital operations, the orbiter would glide down through the atmosphere, red hot, and complete an aircraft-type landing.

A wheel-shaped, 250 foot-diameter, space station was to be the jumping-off point for the Moon. Once it had proved feasible to operate in space more advanced forms of shuttles and space stations were envisaged. The Moon would be studied by a small reconnaissance ship passing within 50 miles (80 km) of the surface, and then would come the actual landing. Three ships would land. There would be two, 160 foot (48 m) high craft carrying 20 men each, with a third of similar external design, carrying 10 men and 30 tons (30,000 kg) of cargo. The Lunar-lander design consisted of a framework collection of cylinders and spheres.

Two books appeared in the United States based upon parts of the initial Collier's articles. "Across the Space Frontier" in late-1952, and "Conquest of the Moon" in 1953, both published by Viking Press of New York.

The magazine extended the programme elaborated at the Spaceflight Symposium – by considering a journey to Mars. Quaintly called a "Landing Boat" by von Braun, the arriving spacecraft glided down to an aircraft-type landing and shed its huge wings, leaving the central fuselage able to take off again vertically. Twelve men in two vehicles were to make the Martian landing. The winged gliders would be assembled in Mars' orbit. A book on the project called "*The Exploration of Mars*" (later revised and retitled "*Project Mars*") appeared in 1956.

Disney

Collier's readers included the Senior Animator at the Hollywood Walt Disney Studios, Ward Kimball. In the Spring of 1954, he suggested that the Studios should prepare a film on "Rockets and Space" for the Disneyland TV programme series then in preparation for ABC-TV. As serious planning proceeded, it was discovered that quite enough material for three hour-length shows would be generated.

Neither Walt Disney nor Dr. von Braun were ever backward in making maximum use of new media for advancing their ideas: now was the age of television. Von Braun, Dr. Heinz Haber and Willy Ley were contracted by the Disney organization as scientific consultants. They were later joined by astronomer Dr. E. C. Slipher from Lowell Observatory, and the nuclear physicist Dr. Ernst Stuhlinger.

Walt Disney with advisers for the "Rockets and Space" TV films. This 1955 picture shows (from left) von Braun, Willey Ley, Disney and Heinz Haber.

© Walt Disney Productions

Rocket scientists and nuclear physicist laboured side-by-side with the originators of Pluto the dog and Donald Duck in envisioning the hardware of the future. A scaled-down version of the Collier's scenario was used. The first show (''*Man in Space*'') discussed the history of rocketry, space medicine, and the launching of a 3-stage shuttle vehicle. The second (''*Man and the Moon*'') showed the building of a space station and a trip to the Moon. The third showed a trip to Mars (''*Mars and Beyond*'').

The Disney programmes were a combination of fact, speculation and cartoon comedy. The films showed shuttles, an earth-orbit space station, freighters and exploration vehicles for the Lunar and Martian landings. They were broadcast in the ''Tomorrowland'' section of the Disneyland series: one in 1955, another in 1956, and the final film in 1957.

The films used the von-Braun design of shuttle, slightly modernised with delta wings. However, the craft had been modified internally: there were now fewer, but more powerful, engines, still using the common propellants nitric acid/hydrazine. The space station was a slightly smaller, but otherwise identical version of the one von Braun had designed for the Collier's articles. However, the Lunar Landing vehicle was to be a 53-feet (15.9 m) long ship crewed by four men. The Martian vehicles also changed. They became a nuclear powered unorthodox design adapted from Dr. Stuhlinger's designs for ion-powered spacecraft.

Those images affected a generation of youngsters; youngsters who later became the scientists and technologists who turned the dream of space flight into reality.

British ''Pioneers''

In Britain there were other influences besides the books from America. Firstly, in April 1950 a new publication for children was launched – *The Eagle* – a ''comic'' with quality strip cartoons. The leading character, and now probably better known than the title of the paper which carried his adventures, was ''Dan Dare – Pilot of the Future''. He was created and drawn, in a distinct ''Bonestell'' style by the 30-year old artist Frank Hampson.

Dan Dare starred in every one of the original Eagle's 980-odd issues, but is best remembered for the Age of Hampson: 1950–59. Hampson pioneered cinematic techniques in strip cartoons, with distance shots, wide-angle views and careful lighting. Cross-hatching and other novel graphics enhanced the majesty of outer space. The result was so vivid that explanatory text could be minimised with whole sequences narrated in pure visual form.

When words were used, they contained many pleasing embellishments. Officer/Ranker tensions were sometimes parodied by Dare and his batman, Digby, whilst the war of the sexes was represented by sharp-edged repartee between the martinet Sir Hubert Guest and the feminist Jocelyn Peabody. Hampson was his own best script-writer. He relinquished this task in 1953, but compensated the readers with even more polished art as head of a Dare studio team numbering as many as 8 people.

Model spaceships and installations were built so they could be accurately drawn from various lines of sight. Staff members served as character models. Extensive archives held blueprints of the strip's humans and aliens, their weapons, accoutrements and personal histories. Dan Dare himself was a Colonel in the Interplanet Space Fleet of 1995. ISF was very much the RAF in green uniform, with a fair sprinkling of ''kites'', ''prangs'' and handle-bar moustaches. But this solid, detailed service background lent credibility to dashing adventures on distant planets.

Even these were kept within the bounds of scientific possibility. Known dead planets were not peopled with advanced civilizations. Futuristic vehicles were carefully designed so their workings could be clearly understood. Interstellar journeys were not casually undertaken but involved much talk of Relativity and such like. Within these limits, imagination had full play.

Each new world was given its own detailed history, geography, fauna and flora. Venus – the most thorough creation – even offered an answer to the ancient mystery of Atlantis.

Dan was pitted against marvellously sinister enemies including the supertechnocratic Treens of North Venus lead by one of the most popular aliens ever created in science fiction, the Mekon. There were the decadent feudalists of the Saturnian Empire, the savage warlords of Phantos, even a race of interstellar pirate locusts.

Dan Dare was wholesome and moral. Interplanet Space Fleet was an agency of the UN World Government and mounted arms only occasionally and reluctantly. Dan himself favoured a non-lethal gas pistol. He had no use for lies, treachery or alcohol, yet fortunately for the story-lines the ethical message was mainly implicit.

An air of realism pervaded the Dan Dare cartoon strip. The sheer amount of care and deliberation required to produce such illustrations attracts people

Dane Dare and sidekick Digby in a 1958 issue of the *Eagle*.

© IPC Magazines

to the old series even today. Dare had his own spacecraft called the "Valiant", the prototype of a class of craft – the XC9 cruiser. A space station was designed in 1951 for the cartoon strip. Of a linked-double spherical shape, it was far more sophisticated than the "von Braun model", but they were each designed for differing purposes and ages of space exploration!

Perhaps the greatest British contribution to the lasting popular literature of Space Travel is a book published in 1953, *Dan Dare's Spacebook*. This carries a long article by the first science advisor on the Dan Dare series, former BIS Chairman Arthur C. Clarke, and is illustrated with some of the "*The Conquest of Space*" book pictures from Chesley Bonestell.

A tribute to the nature of the Dan Dare character is in the "Exploration" displays of London's Science Museum, where he appears on several murals alongside the artifacts of real space travel like the Apollo 10 capsule and a full-size model Lunar Lander. (It may be significant that the only photographed person in the entire display is Dr. Wernher von Braun).

Of course Dare had numerous competitors, some more like the Don Quixote/Sancho Panza double act of Dare and Digby than others. However, one competitor stands out as being rather well illustrated. Nowhere near as sophisticated as Dan Dare and his SF world, Space Kingley benefited greatly from having an artist who was so obviously inspired by the Chesley Bonestell illustrations in the "*Conquest of Space*".

A second major UK series influenced by the Collier's magazine articles, though in a somewhat different medium, was "*Journey into Space*". The author was BBC radio producer Charles Chilton. He created Jet Morgan, the spaceship commander, for three, approximately twenty episode, radio series, transmitted from September 1953 until February 1956. Dr. von Braun's shuttle became the main spacecraft of "*Journey into Space*" – named firstly "*Luna*" and later, after some re-engineering, "*Discovery*".

These space vehicles voyaged to the Moon and Mars – in adventures involving flying saucers, hollowed-out asteroids, races of Martian giants and biped armadillos. The tales were of wary and reticent time travellers from the Earth's past, and an attempted invasion of the Earth by Martian Colonists. The radio series were later published as novels – their dust jackets giving for the first time pictures of the spacecraft involved. The artist illustrating them was the one who had worked in the near-photographic style on Space Kingley.

"*Journey into Space*" was a combination of high drama, ethereal sound effects, matter-of-factness and topicality. It was extremely popular – television was still an infant entertainment medium in Britain, with short hours of broadcasting from the BBC and no independent channel at all. The science advisor for the series was BIS member – later President – Kenneth Gatland, and the plausible nature of "*Journey into Space*" is probably directly attributable to the technological data provided by Gatland and the astronomical data provided by author Chilton.

In April 1956 there was a strip-cartoon sequel to the Martian adventures in a quality-competitor of the Eagle publication, *Express Weekly*. Yet another Bonestell-influenced artist illustrated the adventure.

© Ron Jobson

The successors to these fifties characters most of us, even the youngest, will have heard of – *2001, Star Trek, Star Wars, Close Encounters* etc, etc. But all these have arisen against a different background. The real space age, an age of man-in-space, has been happening in parallel. It may be interesting to speculate on how much that has changed the impact of the latter-day Dan Dares. Dare himself has come back in a revamp of the "*Eagle*", a disappointing reincarnation for many who knew the original. But is that disappointment a symptom of the changed circumstances, the different times?

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MOS-1: A JAPANESE LANDSAT

By Dr. J. K. Davies

In 1986, if all goes according to plan, a two stage N-II rocket will rise from the Tanegashima Space Centre carrying Japan's first Earth observation satellite. It will coast until it reaches South America and then, a little less than an hour after liftoff, the second stage will restart to place the satellite into its final orbit. With this launch, Japan will have taken a major step towards establishing an operational Earth resources satellite programme.

Introduction

The decision that Japan should develop both land and sea observation satellites was taken by the Space Activities Commission in 1978. The objectives were two-fold:

(i) to establish the technology for Earth observation satellites,
(ii) to carry out observations of "sea state" and the atmosphere from orbit.

Following this decision, conceptual studies of a Maritime Observation Satellite and a preliminary design were completed in 1978 and 1979 respectively. By July 1981 the basic spacecraft design was established and by September 1982 the project was into its critical review stage.

The MOS-1 Satellite

In keeping with modern trends in spacecraft design, MOS-1 will be a modular construction with both service and mission modules. The mission module will carry all of the scientific instruments, while the service module provides the vital electrical and mechanical subsystems. Both modules are approximately cubic and give the satellite dimensions of about 1.25×1.25×2 m. A three-segment deployable solar array is attached to one side of the body. Total spacecraft weight is expected to be about 750 kg.

MOS-1 will be 3 axis stabilised with attitude control being provided by a set of four momentum wheels. These wheels store angular momentum and can be used to absorb destabilising influences (for example, solar wind pressure) or to slew the craft in any desired direction. A magnetic torquer system can unload the wheels when necessary. For attitude control during the launch phase, and for in-orbit station-keeping, a gas jet system is provided. Attitude control accuracy is expected to be 1° or better in all three axes.

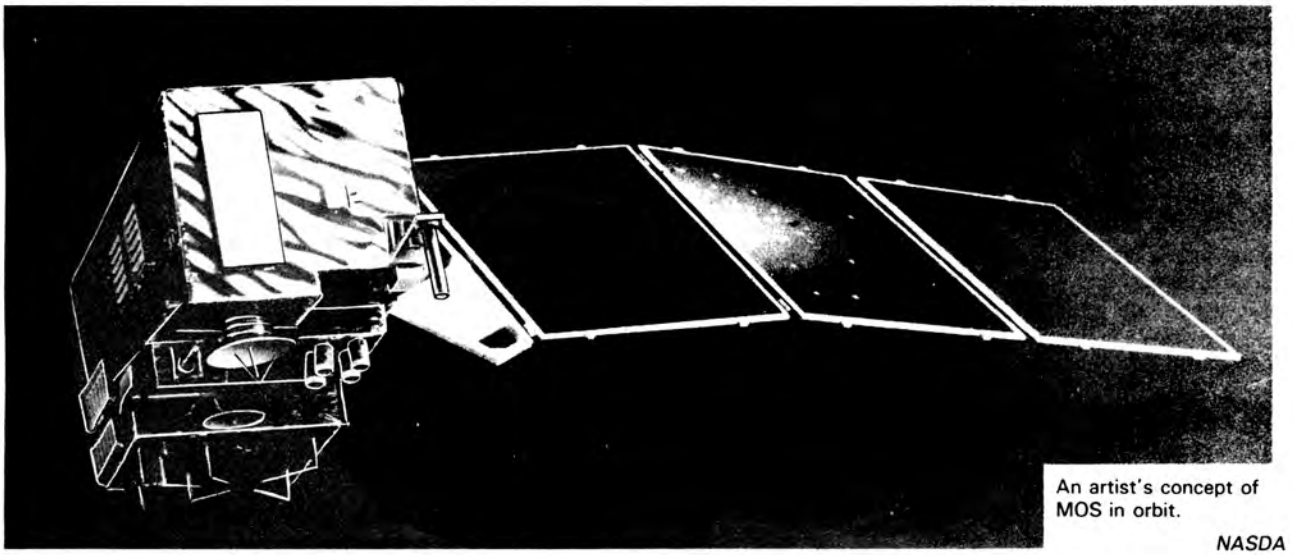
The satellite will be equipped with both S and X band communication systems for transmission of engineering and scientific data and for receiving commands from its operating control centre. A single narrow band tape recorder is provided for housekeeping data.

The Scientific Instruments

Three Earth observation experiments will be carried, plus a Data Collection System (DCS) similar to that of the US Landsats. The DCS will interrogate large numbers of automatic monitoring stations in the oceans and relay their stored information back to Japan.

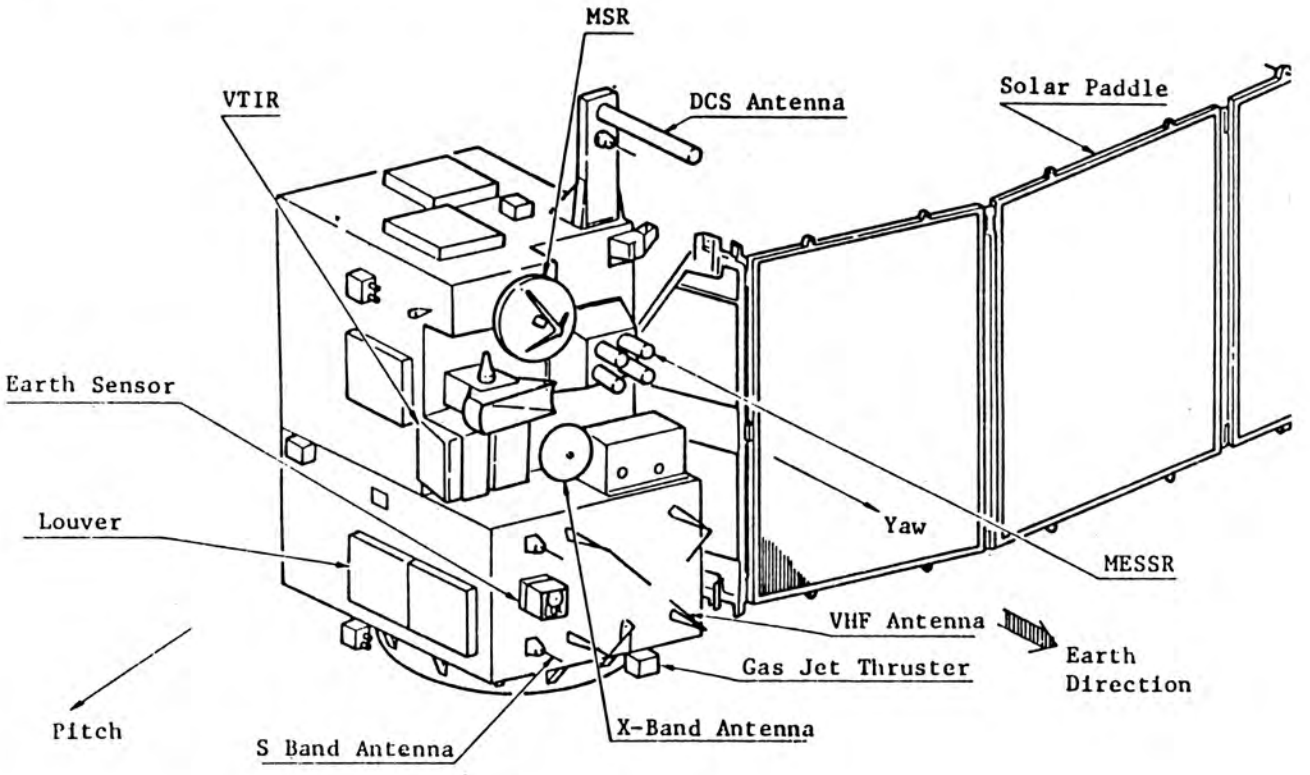
The Multispectral Electronic Self Scanning Radiometer (MESSR) operates in four wavelength bands between 0.51 and 1.1 microns; by measuring the relative brightness in these four bands a sea surface colour can be worked out. Changes in this colour might indicate pollution or plankton rich regions suitable for fishing. Two telescopes are used, each covering two of the wavelength bands. Each contains a prism to split the incoming light into two parts depending on wavelength and two 2048 element charge-couple device detectors on which the measurements are made. The 70 kg MESSR scans in swaths 100 km wide.

Sea surface temperatures will be measured by the Visible and Thermal Infrared Radiometer (VTIR). It



An artist's concept of MOS in orbit.

NASDA



includes a Ritchey-Chretien type telescope which focusses incoming radiation onto visible light and infrared detectors. Scanning is achieved by a mirror, rotating 7.3 times a second, at the front of the telescope which directs the incident light to the optics. The VTIR weighs 25 kg and consumes 35 watts of power.

The Microwave Scanning Radiometer (MSR) is used to measure the water content of the atmosphere. This instrument consists of two Dicke type radiometers which make a conical scan across a 320 km wide swath beneath the spacecraft. The scanning is done by rotating an offset parabolic reflector at about 18 rpm. The MSR weighs 54 kg and draws 60 watts.

Operational Orbit

The planned orbit for MOS-1 is a Sun-synchronous, westerly drifting one with an inclination of 99.1° and a height of 909 km. This will allow it to make 14 revolutions per day, repeating the ground track every 17 days. The orbit will be controlled to keep the ground track deviation to less than 20 km at the equator.

Tracking and Control

Responsibility for operating the satellite will fall to the control centre at the Tsukuba Space Centre. Additional support will be provided by tracking stations in Katsuura, Masuda and Okinowa. Operations will be controlled by Tsukuba based on requests from an operations control system which will coordinate all operations, including liason with foreign groups. The scientific data will be received at the Earth Observation Centre at Hatoyama, Saitama which is currently operating a Landsat ground station. Here the data will be processed, examined, archived and distributed to experimenters.

MOS-1 is the first step in Japan's programme to develop and exploit its own Earth resources programme. It will no doubt be followed by other similar projects in the years ahead.

Acknowledgments

The author would like to thank the National Space Development Agency of Japan for their help in producing this article.

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PERSONAL PROFILE

FREDERICK I. ORDWAY

Introduction

Like many space flight enthusiasts, my interest was first stimulated by science fiction magazines. As best as I can work out from my diaries, I was all of 13 years old at the time. I well recall my first experience with the genre: a second-hand *Amazing Stories* magazine of January 1939 featuring a tale by Otto Binder entitled "I, Robot."

During 1940 and throughout 1941, I devoured every science fiction magazine I could lay my hands on; and, at the same time, began reading books on Solar System astronomy and whatever was then available on space flight. In January 1941, I joined the American Rocket Society and have been a member ever since (it is now the American Institute of Aeronautics and Astronautics).

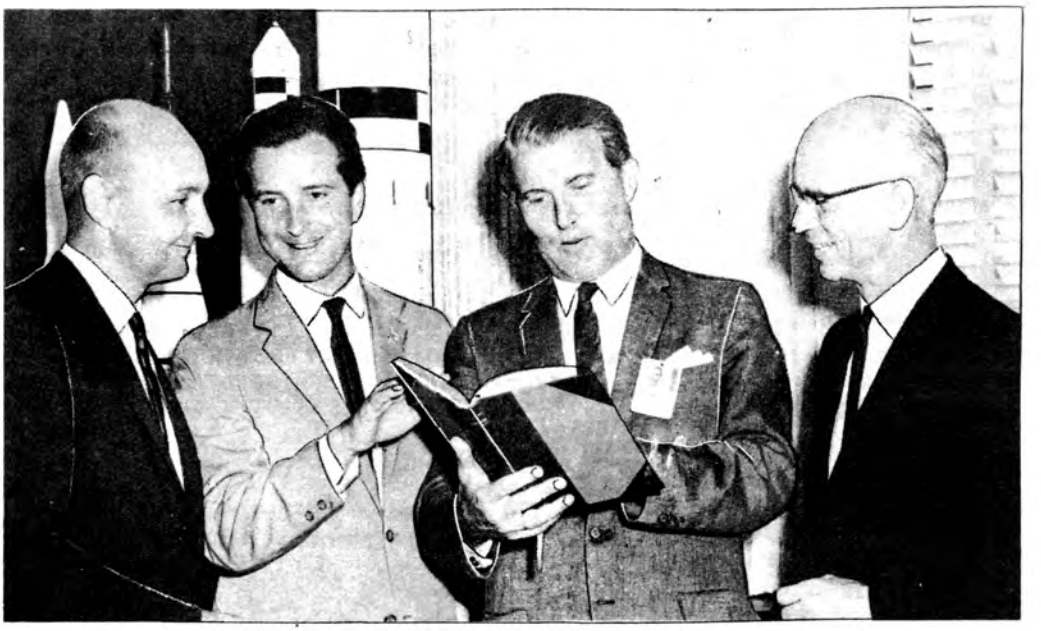
The World War II years were spent in school in Washington, D.C., except for some nine months in 1945 when I saw US Naval Reserve duty. Following the cessation of hostilities with Japan, I entered Harvard University from where I graduated in 1949 with a B.Sc. degree in geosciences, petroleum and mining. Two years later, I made the transition to the object of my dreams: rocketry and astronautics. On 19 September 1951, I received an offer as assistant engineer, Engineering Division, at America's pioneering rocket engine company, Reaction Motors, Inc. I would earn $89 for a 45-hour week. Eighty-nine dollars was not much compared to what I had been getting working for an oil company; overseas pay was quite high and one also enjoyed such perks as free housing and country club. But rocketry and the prospect of space flight won out over petroleum and mining. I joined RMI, then involved in such projects as the Viking sounding rocket and motors for the Bell X-1, Douglas D-558-2, and Republic XF-91 aircraft.

I had not been long at RMI when I began taking an active interest in the affairs of the New York section of the American Rocket Society and in writing and lecturing on the promise of space travel. At the ARS meetings, I became closely involved with G. Edward Pendray, Willy Ley, Alfred Africano, and other leading proponents of astronautics.

Fred Ordway beside the bust of Robert Scott at McMurdo Base in Antarctica, 1970.

To Europe

I left RMI in mid-May 1953 to spend a year or so in Europe. My aims were to attend the 1953 and 1954



1963: Presentation to von Braun of a book published in his honour. *Left to right*: George Bucher, Fred Ordway, von Braun & Ernst Stuhlinger.

IAF congresses, to study at the University of Paris, to travel around the UK and Europe to meet as many space fight enthusiasts as I could, and to take advantage of the strong purchasing power of the US dollar and acquire as much literature as possible on space and related subjects.

My wife and I scheduled our New York departure so as to reach London in time for Queen Elizabeth II's coronation. In London on 2 June, we arose early to secure our places on Piccadilly to watch the elegant procession. Six days later, I spent the morning in the offices of the BIS in Bessborough Gardens.

Although I had been the only American to attend the First International Astronautical Congress (in Paris, 30 September to 2 October 1950), it was only as a passive observer. I decided to take a more active role in the 1953 fourth congress in Zurich. There, I got to know many leading space flight experts and enthusiasts, including Theodor von Kármán; Wernher von Braun; Frederick C. Durant; Leslie R. Shepherd; S. Fred Singer; Eugen Sänger; Ake Hjerkstrond; Teófilo M. Tabanera; and Arthur C. Clarke.

In 1952, I joined the British Interplanetary Society and in early 1954 became member No. 52 of the newly-organised American Astronautical Society. The AAS originally consisted of members of the British Interplanetary Society resident in New York City and vicinity. I subsequently joined the AAS board of directors and for a period edited the *Journal of Astronautics*.

My notes during 1954 and 1955 showed that I was almost overwhelmed with work, in the Guided Missiles Division at Republic Aviation, with my rapidly growing writing commitments, with numerous speeches, with the American Astronautical Society, and with seemingly endless events such as the opening of Viking rocket hall at Hayden Planetarium in New York on 30 June 1955.

All the while, I was making plans for the Sixth IAF Congress scheduled to take place in Copenhagen during the first week of August. On 30 July we heard the thrilling news that President Eisenhower had just announced that the United States would seek to place an artificial satellite into orbit around the Earth during the International Geophysical Year (or sometime before the end of 1957). Space flight was coming of age!

With von Braun

The 7th of October 1955 turned out to be a particularly significant day for me. Much of it was spent at dedication ceremonies in New Jersey for a new Reaction Motors facility (I had always kept close contact with my many friends there), capped by a rocket engine firing. Then, in the evening in New York, I attended a meeting with fellow AAS members that we had organised at Hayden Planetarium. "When I think of the job of sending out nearly 2000 invitations," I wrote the next day in my journal, "I shudder, since we only pulled in [for the meeting] about 100. We netted, however, [Willy] Ley, [Carsbie C.] Adams, [Wernher] von Braun, [Joseph] Chamberlain (Director of Hayden) and other notables." After the meeting, a small group of us, including Ley, Adams, Ronald C. Wakeford, and von Braun, went to the Green Room of the Edison Hotel for dinner and drinks. There, we enthusiastically discussed space flight until 4 a.m. That long evening with von Braun would have far-reaching consequences.

The early days. Working at Reaction Motors Inc. in November 1951.

During the ensuing months, von Braun and I maintained close contact. Meanwhile, several friends and associates of mine from Republic, Bell Aircraft, Sperry Gyroscope, and Grumman formed a consulting group that became the General Astronautics Corp. At different points, we resigned from our respective affiliations and struck out on our own. Shortly after I had done so, an unexpected event occurred. Wernher von Braun was its author.

On the morning of the 28 March 1956, after a leisurely breakfast at the Harvard Club in New York, he suddenly asked me, "Fred, how would you like to join me at the Redstone Arsenal down in Huntsville? We need enthusiastic people like you who are not afraid of hard work.'

Huntsville, Alabama? To a New Yorker in 1956, that seemed remote indeed. Anyway, despite the great honour of working for Wernher von Braun, I didn't feel I could simply walk away from our new group and leave my associates behind. When I expressed my reservations, von Braun offered an immediate solution. He said something to the effect that the Army Ballistic Missile Agency would contract with our new company, General Astronautics, for the services of the lot of us (five or six at the time) and that sometime in the future I could join his team in person. Meanwhile, there was more than enough work for all!

And so it turned out. On the 5th of April, I entered the gates of Redstone Arsenal for the first time and reached a large, modern building that was the headquarters of the Army Ballistic Missile Agency. According to my journal: "After a brief talk with Wernher von Braun, I (toured the ABMA facility) with Heinz Hermann Koelle . . . This visit was of Secret classification, and included the fabrication-assembly depot of the Redstone missile (we made a complete inspection of the large warhead, the North America 75,000-lb thrust engine, airframe, etc.), drawings of satellite configurations, balance-testing of multistage components, IRBM [the emerging Jupiter] drawings, the huge test facilities where whole missiles can be 'strapped' in for

static firings, the guidance development lab, and so on. Everything from design to production is run under German supervision, and the number of projects of an astronautical nature is highly interesting from the point of view of General Astronautics. At noon lunched with von Braun, following which discussions were held relative to the activities that could be taken by GAC for Redstone. It was decided that an 'open structure' survey-study 'G-2' type contract would be set up involving preliminary dollar total in the low thirty thousands. Into such a contract, specific task assignments would be fed (involving) . . . satellites, power supplies, feasibility of using a given telemetry system, etc. Later, in conference with contracting officers, it was established that GAC would receive a request to submit a proposal. We would then offer so many man-hours at such and such a rate . . . for the first phase . . . At 1900, I went over to the von Braun's for dinner and further talks. He and his wife were most hospitable, the cuisine was fine, the drinks smooth. We looked over the galleys of [Willy] Ley's and his forthcoming Mars book, went into more details of the Redstone-GAC agreements, and discussed my eventual transfer as special technical assistant . . . at ABMA."

In due course, General Astronautics negotiated a contract with ABMA through the Army's New York Ordnance District in New York. Our work was to encompass studies ranging from high altitude vehicle instrumentation to missile welding techniques. Three of our five-man company would move to Huntsville; the other two plus support staff would remain in New York.

For a while, I commuted by train and air between New York and Huntsville. In those "missile gap" days, the United States was playing catchup to the Russians, who we assumed were well ahead in the long-range rocket technology field. ABMA was expanding rapidly. More so, to my chagrin, than the availability of local housing!

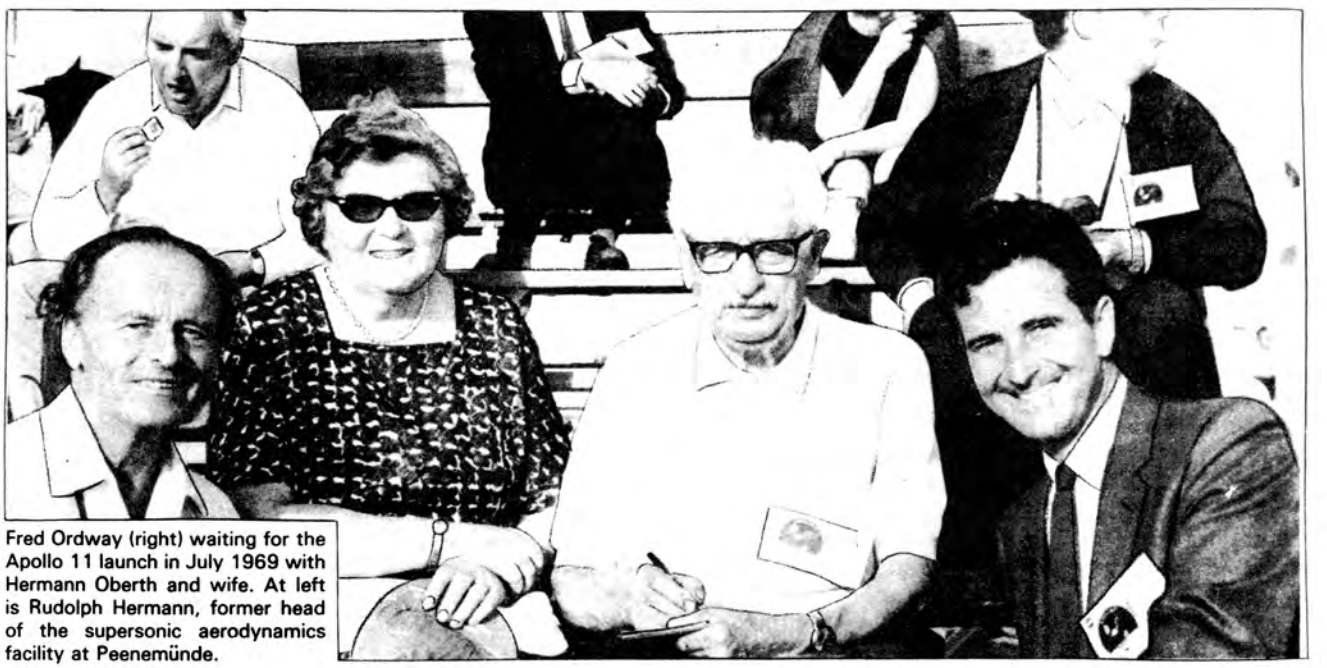
Our direct supervisor in ABMA was Dr. Ernst Stuhlinger, though we continued to have frequent contact with Von Braun, Koelle, Gerhard Heller, and Hermann Oberth who had arrived from Germany to serve as special consultant to the Army. My two company colleagues who had come down from New York, Wakeford and Canney, also settled atop Monte Sano.

Honouring my earlier understanding with Von Braun, in 1959 I joined the Army Ballistic Missile Agency as assistant to the director of the ARPA/NASA Project Office under Dr. Oswald Lange. Later, the office became the Saturn Systems Office. When, in mid-1960, ABMA's Development Operations Division (the Von Braun team) was transferred to NASA's new George C. Marshall Space Flight Center, I became chief of the Space Information Systems Branch. In less than a year, President Kennedy would propose the Apollo programme to Congress.

My career in Huntsville was broken by a couple of years (1965–66) working with Arthur C. Clarke, Stanley Kubrick and others as technical advisor to the film *2001: A Space Odyssey*. My wife, sons and Huntsville-born daughter Aliette Marisol all accompanied me to London where the film was made.

Returning to Huntsville in 1967, I joined the astronautics research staff at the University of Alabama in Huntsville under Dr. Rudolph Hermann, former head of the Peenemünde supersonic aerodynamics facility. Later, I became Professor of Science and Technology Applications and head of the Science and Technology Evaluation division. Most of my work involved contractual studies for the nearby Marshall Center. I continued to lecture and write without cease during my seven university years, remained involved with professional society affairs, and travelled regularly to Cape Canaveral and other facilities around the country. I even went to the South Pole!

That was in 1970, while Apollo was in full swing and we were all dreaming of such follow-on activities



Fred Ordway (right) waiting for the Apollo 11 launch in July 1969 with Hermann Oberth and wife. At left is Rudolph Hermann, former head of the supersonic aerodynamics facility at Peenemünde.

Enjoying a swim with von Braun, 1957.

as the establishment of a base on the Moon. Under the auspices of the National Science Foundation's Project Deepfreeze, and with Von Braun's encouragement (he had recently been to the Antarctic) I visited the McMurdo, Scott, South Pole and other stations and such sites as the Dry Valleys with the aim of learning how the nation's long experience in the Antarctic regions might be applied to the Moon.

A year later, the NSF supported my travel to the Soviet Union where I presented to a USSR Academy of Science colloquium a long paper on the evolution of the space station concept. While in Russia, I visited Tsiolkovsky's home in Kaluga and the grand sights of Leningrad. The Science Foundation subsequently sent me on a lecture tour of New Zealand to describe the Skylab programme and its experiments to astronomical and astronautical society, university and other audiences.

Following Von Braun's departure from Huntsville to NASA headquarters in Washington and the completion of the Apollo and Skylab endeavours, life in Huntsville became somewhat less challenging. So, in 1974, I moved to Washington for a period of consultancy with the National Science Foundation's Science and Technology Policy Office. Then, a year later, I became first consultant and then special assistant to the Administrator Robert C. Seamans, Jr. of the Energy Research and Development Administration.

At ERDA and, later, the Department of Energy (into which ERDA was folded in October 1977), I became heavily involved in energy policy and planning and in international cooperative programmes.

I maintain my professional society involvement, serving on the AIAA International Affairs Committee and History Committee, the American Astronautical Society History Committee, and the Consortium of Affiliates for International Programs of the American Association for the Advancement of Science. I am also active with the National Space Institute and the National Space Club, and maintain an unbroken membership in the BIS.

JOIN US TO CELEBRATE OUR 50th ANNIVERSARY

This October will see the Society reach its 50th Anniversary – half a century of promoting space travel for the benefit of mankind. To mark the event, we are holding a celebration dinner at Society headquarters during the evening of Friday, 21 October 1983 for members and Guests of Honour.

Why not join us to mark a significant event in the Society's history? Places are restricted so early application is essential.

If you would like to attend, please write to the Executive Secretary for further information, enclosing a reply-paid envelope.

If necessary, another dinner will be held the following evening at HQ on Saturday, 22 October.

The evening will be highlighted by the presentation of a Golden Jubilee Plaque by the American Institute of Aeronautics and Astronautics, messages of congratulations from around the world and – of course – the dinner itself.

The celebration is open to members, who may introduce one guest each. The cost is £15 per person, which covers an apperatif, a 4-course dinner and wine.

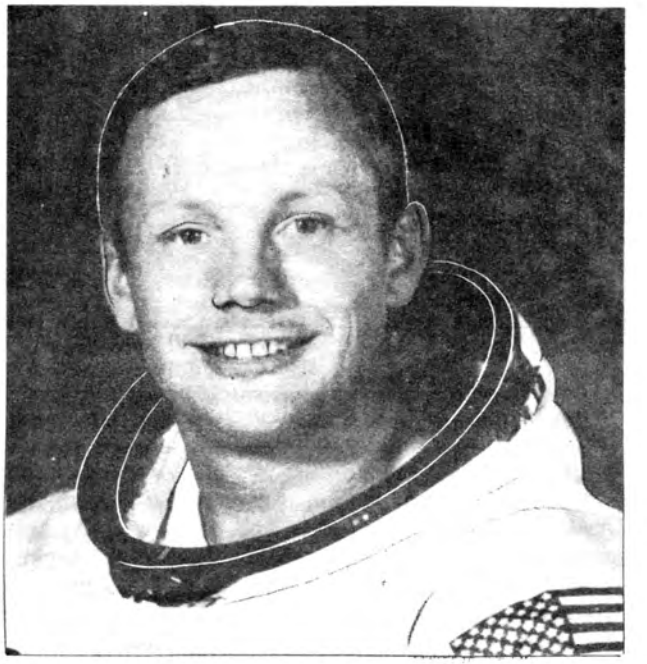
1933 50th 1983

ANNIVERSARY

THE NEIL ARMSTRONG AIR & SPACE MUSEUM

By Keith T. Wilson

Neil Armstrong, the first human to set foot on the Moon, was born on 5 August 1930 in rural Ohio. Although the Armstrong family lived in several Ohio cities, Neil considers Wapakoneta to be his home town. The Neil Armstrong Air and Space Museum, opened in Wapakoneta on 20 July 1972, recalls the historic Apollo 11 Moon-landing mission, and stands as a tribute to its namesake. The museum recently celebrated its tenth anniversary and the 13th of the Apollo 11 lunar landing.

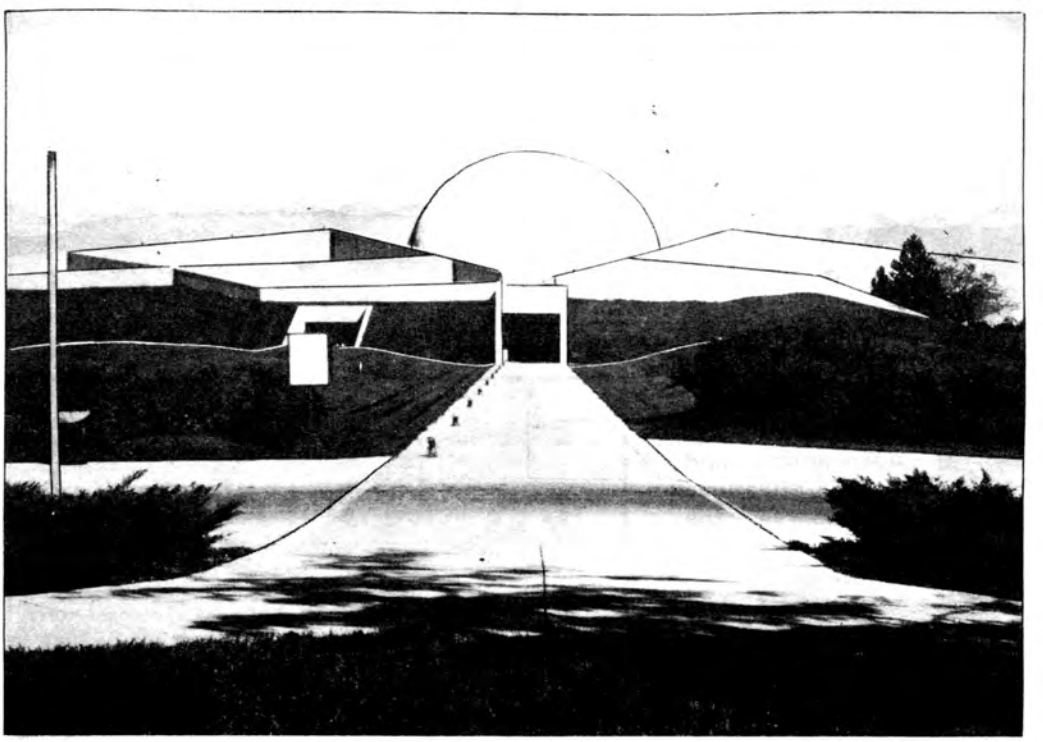


Neil Armstrong.

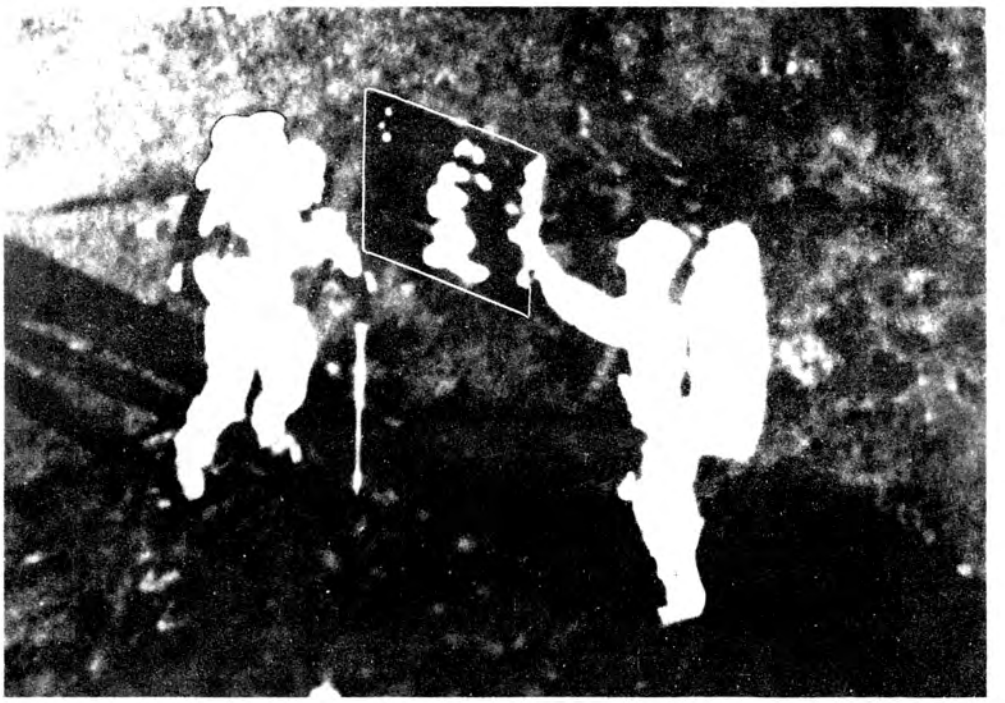
The museum is situated on the eastern side of Wapakoneta close to the Toledo-Dayton highway. The building itself is a contemporary structure looking more like something from a science fiction film than a museum. Soil has been moulded around the base and sides, leaving only concrete roof beams exposed and an 18 m diameter white dome housing an astro-theatre.

Major space exhibits are on loan from the Smithsonian Institution's National Air and Space Museum, NASA and the US Air Force Museum. One of the first exhibits visitors notice as they approach the building is the F5D Skylancer aircraft, flown by Neil Armstrong for NASA and the Air Force in the early 1960's.

The interior of the museum is divided into a number of galleries. The main area features relics of Ohio air and space achievements. Early flight is recalled by a balloon basket and trophies won by balloonist Warren Rasor. Suspended from the ceiling is the large dirigible airframe from Toledo II, the first manned powered flying machine to pass over New York. A reconstructed Wright brothers Model G Aero-boat is also shown. Standing on its tail in this gallery visitors can also see the 1946 Aeronca 7AC Champion light aircraft in which Armstrong learned to fly at the age of 16. Close by, a North America-built H-1A rocket engine, of the type



The Neil Armstrong Air & Space Museum in Wapakoneta, Ohio.

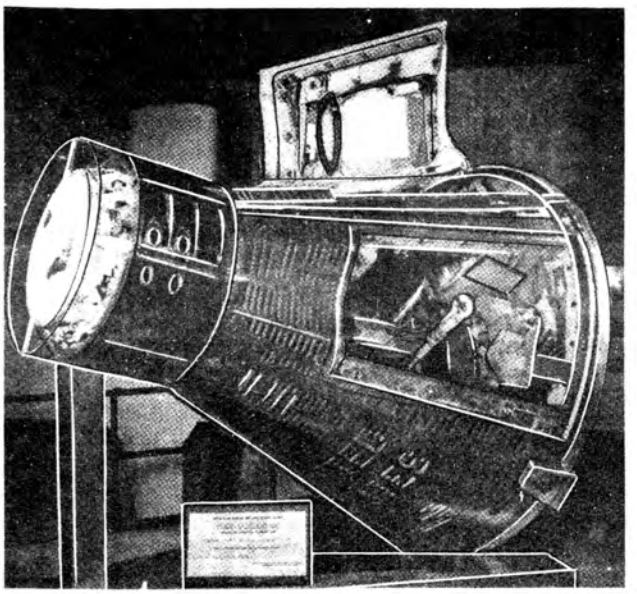


No good pictures of Armstrong on the lunar surface were taken; he kept the still camera himself throughout the Moonwalk. This picture is from the automatic 16 mm camera mounted inside the Lunar Module looking through a window (Armstrong on left).

NASA

used during the initial phases of the Apollo programme, is displayed horizontally on a trolly.

The Space Flight Gallery has as its main feature the Gemini 8 spacecraft used by Armstrong and Dave Scott to carry out the first manned docking mission in March 1966. The capsule, enclosed in clear perspex, is tilted onto its left side where Armstrong's hatch has been removed to clearly show the interior. Scott's hatch is in the open position. Visitors can clearly see the spacecraft seats and controls and can appreciate the cramped conditions in which Gemini astronauts worked.



The Gemini 8 capsule in which Armstrong and Scott achieved the first manned docking in space.

Other exhibits here include Armstrong's Gemini and Apollo 11 back-up spacesuits. Both are enclosed in viewing cases where the bulky nature of the Apollo suit is evident when compared with the lightweight Gemini suit. The remainder of this gallery is taken up with exhibits illustrating Armstrong's boyhood interest in aviation, including examples of his early model-building.

From the Space Flight Gallery the visitor proceeds through a tunnel to a video room where an Apollo 11 tape is continuously shown on a television monitor. There is also a mini-theatre where the progress of US manned space flight is recounted. Beneath the museum's dome is the large astro-theatre, used for audio-visual presentations. Here visitors can witness an imaginary trip to the Moon, or see a presentation on the Apollo 11 Moon landing.

Approximately 25 paintings by American artists and mementoes presented to the museum by Neil Armstrong are displayed in another area, including an American flag taken to the Moon by Armstrong and the watch which he wore on the Apollo 11 mission. The museum regularly issues commemorative covers to mark Apollo 11 and Neil Armstrong anniversaries, and sells books, postcards and miscellaneous items related to Armstrong.

Between 65,000 and 80,000 people visit the museum annually; Armstrong himself has done so on a number of occasions. Although small compared to other US space museums, the Neil Armstrong Air and Space Museum provides a fitting tribute to the first man to set foot on the Moon.

Acknowledgement

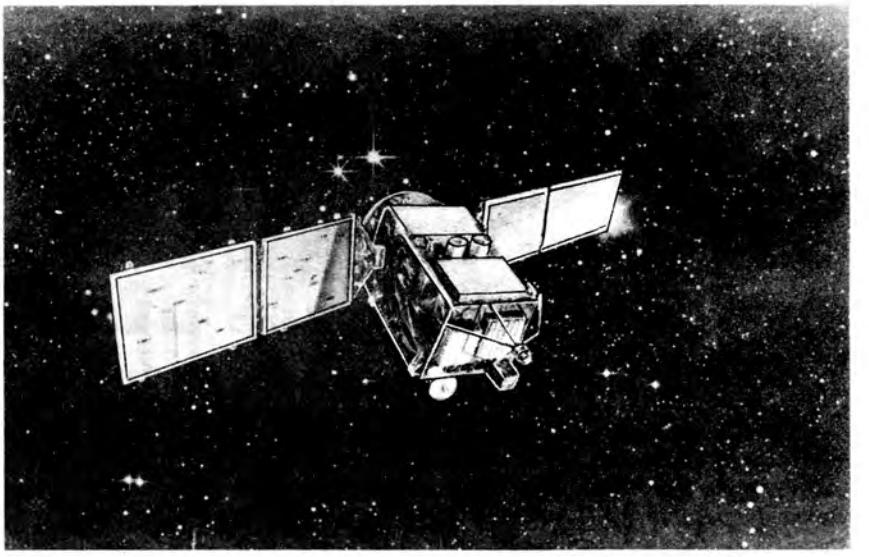
I would like to thank John Zwez, manager of the museum, for providing material used in this article.

SATELLITE DIGEST – 165

Robert D. Christy
Continued from the June issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.



Kiku 4 was launched by the Japanese on 3 September 1982 as a technology-proving satellite, testing control systems, solar arrays and an ion engine.

NASDA

IRAS 1983-4A, 13777

Launched: 0230, 26 Jan 1983 from Vandenberg AFB by Delta 3910.
Spacecraft data: Cylinder 3.6 m long and 2.0 m diameter, mass about 1000 kg.
Mission: The study of infrared radiation sources in space. The mission is a joint venture involving the US, the UK and the Netherlands.
Orbit: 896×913 km, 103.10 min, 99.10 deg.

COSMOS 1438 1983-5A, 13779

Launched: 0840, 27 Jan 1983 from Tyuratam by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical reentry module, an instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6 m, diameter (max) 2.4 m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 11 days.
Orbit: 175×293 km, 89.24 min, 70.40 deg, manoeuvrable.

SAKURA 2A 1983-6A, 13782

Launched: 0840, 4 Feb 1983 from Tanegashima Space Centre by NII.
Spacecraft data: Cylindrical, spin stabilised spacecraft enclosed in drum-shaped solar panel with de-spun antenna and reflector. Length 2.05 m (3.29 m incl. antenna), diameter 2.18 m and mass 670 kg at launch including 355 kg of fuel and tank pressurant. Communications carried include telephone, television and data. There are six K Band channels with uplinks in the range 27.5 to 29.25 GHz and downlinks between 17.7 and 19.45 GHz used by stations on the main Japanese islands. There are also two C Band channels (uplink 5.925 to 6.425 GHz and downlink 3.7 to 4.3 GHz) for communications between the main islands and remote islands of the group.
Orbit: Geostationary above 130 deg east longitude.

COSMOS 1439 1983-7A, 13784

Launched: 1130, 6 Feb 1983 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1438.
Mission: Military photo-reconnaissance, recovered after 16 days.
Orbit: 160×295 km, 89.10 min, 70.35 deg, manoeuvrable.

OPS 0252 (5 payloads) 1983-8A,B,E,F&H.

Launched: 1400, 9 Feb 1983 from Vandenberg AFB by Atlas.
Spacecraft data: Not available.
Mission: Ocean surveillance using radar.
Orbits: (approx) 1050×1170 km, 107.5 min, 63.4 deg.

COSMOS 1440 1983-9A, 13793

Launched: 0710, 10 Feb 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1438.
Mission: Photo reconnaissance, recovered after 14 days. All or part of the payload was an Earth resources package.
Orbit: 260×275 km, 89.89 min, 82.33 deg.

COSMOS 1441 1983-10A, 13818

Launched: 1000, 16 Feb 1983 from Plesetsk by A-1.
Spacecraft data: Possibly based on the Meteor satellite body with a cylinder, length about 5 m, diameter about 1.5 m and mass around 2000 kg.
Mission: Electronic reconnaissance.

Tenma 1983-11A, 13829

Launched: 0515, 20 Feb 1983 from Kagoshima Space Centre by Mu 3S.
Spacecraft data: Not available.
Mission: Eighth Japanese scientific satellite, carrying five sets of instruments aimed at producing X-ray observations of stars and galaxies. The instrumentation consists of a scintillation proportional counter, a transient x-ray source monitor, focussing x-ray collector, a radiation monitor and a gamma ray detector.
Orbit: 488×503 km, 94.38 min, 31.49 deg.

UPDATES:

Cosmos 1426, 1982-120A was recovered 1983 Mar 5 after 67 days.
Cosmos 1437, 1983-3A mission should read "electronic reconnaissance."

MILESTONES

April 1983

9 Shuttle Orbiter *Challenger* lands in California to end the sucessful STS-5 mission after 5d 23m 42s. On 5 April the 20,400 kg TRDS satellite and its IUS propulsion stages were released; a failure during the second stage burn left it in an orbit of 35,000 by 22,00 km, instead of a geostationary path. Controllers believe they can use the satellites own thrusters to correct the orbit over the next 2 weeks. On 7 April, Musgrave and Peterson make a 3½ hr EVA to test equipment and procedures.

11 Engineers conclude that contact with the Viking 1 Mars lander, lost since last November, will probably not be reestablished. There is a possibility, however, that Viking's own memory will cause transmissions to begin again on 5 May.

11 President Reagan requests the US Interagency Group for Space to study the possibilities for the US manned space programme, including a permanent space station. The report will be made this autumn.

16 Shuttle *Challenger* returns to the Kennedy Space Center to begin processing for the 9 June launch of STS-7.

17 NSA's Solar System Exploration Committee's report recommends four low-cost projects: Venus Radar Mapper (1988); Mars orbiter (1990); Mars orbiter (1990); comet rendezvous/asteroid flyby (mid-1990's); and a Titan probe (c. 1990). Others, such as Mars sample return of surface rovers, are considered too costly.

21 Soyuz T-8 cosmonauts Vladimir Titov, Gennady Strekalov and Alexander Serebrov fail to approach close enough to Salyut 7 to dock. They land the following day.

21 The NOAA-E weather satellite is now stable in orbit following problems after separtation from its Atlas E launcher on 28 March.

26 The final launch readiness review on Europe's Ariane L6 is delayed until 17 May because of schedule slippages. The 3 June launch target is now "tight".

28 The GEOS 6 geostationary meteorological satellite is launched from Cape Canaveral by a Delta 3914. It is due to arrive at its operating position at 135 deg. West on 12 May.

May 1983

2 Two 40 minute test burns of small thrusters aboard the TDRS satellite orbited by Shuttle STS-6 indicate their prolonged use can shift the satellite to its geostationary target orbit. Launch target for STS-7 is 16 June, for STS-8 11 August.

11 Comet Iras-Araki-Alcock 1983D approaches to within 4.5 million km of the Earth. The comet was discovered on 26 April in data from the IRAS infrared astronomical satellite, and independently observed on 3 May by two amateur astronomers in Japan and England. See the end of this issue for further news.

DO YOU KNOW?

Can you identify the celestial body below? What is significant about the picture?

Answer: It is the Moon (no prizes for guessing that!). Specifically, it was the first time that the far side had been seen, courtesy of the Soviet Lunik 3 in October 1959. It showed that there are far fewer lunar "seas" on the far side (the large dark areas).

DO YOU REMEMBER?

25 Years Ago . . .

23 June 1958. US Air Force issues contract for the F-1 rocket engine, eventually used on the Saturn 5.

16 July 1958. Congress passes the National Aeronautics & Space Act. NASA comes into being on 1 October.

20 Years Ago . . .

25 June 1963. X-15 No. 1 brings the project total to 86 flights for the three craft.

1 July 1963. NASA selects Boeing for 4-month study of a lunar base to follow on from Project Apollo.

15 Years Ago . . .

10 August 1968. NASA Associate Administrator Dr. George Mueller describes NASA plans at a BIS meeting for Space Shuttle.

10 Years Ago . . .

18 June 1973. The Skylab 2 astronauts break space endurance record, previously held by the Soyuz 11 crew.

21 July 1973. The Soviets launch the Mars 4 probe, followed by Mars 5 (25 July), Mars 6 (5 August) and Mars 7 (9 August).

5 Years Ago . . .

15 June 1978. Soyuz 29 cosmonauts Kovalyonok and Ivanchenkov begin their 140 day flight aboard Salyut 6.

11July 1978. NASA's Group 8 astronauts began their training at the Johnson Space Center.

D. J. SHAYLER

BOOK NOTICES

Evolution of the Universe
I. D. Novikov, Cambridge University Press, 176pp, 1982, £7.95.

There is nothing which excites the imagination more than the evolution of the entire Universe. The aim of this book is to show, to a general readership, how the mysteries of the Universe at large are being unravelled. It begins with a description of the expansion of the Universe – its discovery, meaning and consequences and then shows how the application of Einstein's theory of relativity to cosmology provides the basis for a more profound understanding.

The central core of the book deals with the early hot Universe and the formation of structures within it. This topic has been developed considerably by several Soviet astrophysicists of late, of whom the author is one. It concludes with speculations on the future course of cosmological research, including matter and anti-matter, an oscilating Universe and even contemplation of primordial black and white holes.

Kinematics, Dynamics and Structure of the Milky Way
Ed. W. L. H. Shuter, D. Reidel, 392pp, 1983, $54.50.

Galactic astronomy is at present in a state of turmoil. The reason for this is that observational astronomers are accumulating a wealth of new data, often from previously inaccessible regions in the electromagnetic spectrum such as the submillimetre range and the gamma radiation range and, at the same time, interpreters and theoreticians are developing new techniques and perspectives which are being applied to understand the new information and re-evaluate previously collected data.

The papers in this volume present new data and ideas that have emerged since the last major symposium on the subject – "The Large-Scale Characteristics of The Galaxy" edited by W. B. Burton, D. Reidel, 1979 – and should greatly assist all those attempting to piece together a coherent picture of our Galaxy.

Cosmochemistry and the Origin of Life
Ed. by C. Ponnamperuma, D. Reidel, 369pp, 1983, $63.

Using an interdisciplinary approach, this volume brings together current knowledge under a single theme, including some of the most recent discoveries related to interstellar molecules on the one hand and the Earth's earliest sediments on the other.

Beginning with the Big Bang and the synthesis of the chemical elements, the book explores the question of organic molecules in space and then relates these to comets and planetary environments before focusing on Earth. In this section, attention is given to chemical composition and climatology of the Earth's early atmosphere, the earliest known sediments, and molecular fossil record, all with an eye to the chemistry necessary for the origin of life.

Man and the Planets
D. Lunan, Ashgrove Press, 306pp, 1983, £9.50.

The object of this book is to assess the resources of the Solar System and to indicate how, one day, man may possess the capacity to utilise them. The reference to present and proposed means of space transportation include a description of the Society's Daedalus study, besides ideas on the colonisation of the Solar System and the establishment of mobile space colonies.

The author advances many suggestions on how the environments of other worlds might be exploited, such as by utilising the heat of Mercury or the vast quantities of chemical isotopes on Jupiter. He even considers more remote possibilities such as the creation of a new Sun on the fringes of the Solar System from the material which may exist there.

This is a thought-provoking work. It indicates, once more, that man is still only poised on the threshold of space exploration.

Some of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Answer to quiz on p. 312.

1. Buzz Aldrin.
2. Miranda, Ariel, Umbriel, Titania, Oberon.
3. Asaph Hall (1877).
4. Harrison Schmitt (Apollo 17, geologist).
5. Japan.
6. Orbiting Solar Observatories.
7. Lebedev & Berezevoi (211d).
8. 2000 tonnes.
9. Engle & Truly.
10. Kepler.
11. Venus Radar Mapper.
12. Saturn, in its rings.
13. Luna 2 (September 1959).
14. Luna 9 (February 1966).
15. Luna 10 (April 1966).
16. Mars 2 capsule (December 1971).
17. Valentina Tereshkova (Vostok 6).
18. Gherman Titov (Vostok 2, 1961).
19. Explorer 1 (1958).
20. InfraRed Astronomical Satellite.
21. "Einstein" was the HEAO 2 observatory.
22. US National Air & Space Museum, Washington, D.C.
23. Voskhod 1 (October 1964).
24. Indonesian domestic communications satellites.
25. Communications satellites leased by their builders, Hughes.
26. Long Duration Exposure Facility, will be cast off by the Shuttle and retrieved on later flight.
27. (i) Philip Cleator.
    (ii) A. T. Lawton.
28. Svetlana Savitskaya (1981).
29. (i) A quasar, PKS 2000-330.
    (ii) 12,000 million.
30. On Mars – it is the Viking 1 lander.
31. Musgrave & Peterson on STS-6.
32. The Topography Experiment satellite, to study the oceans.
33. 110 mins.
34. (i) 11.1 km/s (24,800 mph)
    (ii) 620 km/s (139,000 mph)
35. Lyndon Johnson (May 1963, then US Vice-President).
36. V-2/WAC Corporal (July 1950).
37. Discoverer 13 capsule (August 1960).
38. *Liberty Bell 7*.
39. James Lovell (Apollos 8 and 13)
40. No. 7.
41. USSR (1957), USA (1958), France (1965), Japan (1970), China (1970), UK (1971), India (1980).
42. Neil Armstrong.
43. Walter Schirra (Mercury 8, Gemini 6, Apollo 7).
44. Explorer 6 (Aug 1959).
45. Erik Quistgaard.
46. Luna 16 (1970), Luna 20 (1972), Luna 24 (1976).
47. James Beggs.
48. Mercury & Venus.
49. International Solar Polar Mission.
50. Four.
51. Sweden, Finland, Norway.
52. Jean-Loup Chretien.
53. Galileo (1650).
54. Triton & Nereid.
55. All called Viking.
56. Neptune and Pluto.
57. A JPL-proposed Sun probe.
58. (i) Moon;
    (ii) Venus;
    (iii) Mercury;
    (iv) Mars.
59. Japanese Halley's Comet Probe.
60. It is being used to detect distress beacons of crashed aircraft, boats in trouble, etc.

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

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NOTICES OF MEETINGS

Lecture

Title: **SHUTTLE BOOSTER RECOVERY**

by F. I. Tallentire
Martin Marietta Aerospace

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **20 July 1983,** 7.00–9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

38th Annual General Meeting

The 38th Annual General Meeting of the Society will be held in the Lancaster Room, Caxton Hall, Caxton Street, London, SW1 on Saturday **24 September 1983,** commencing 3.00 p.m.

Details of the Agenda will appear in *Spaceflight* in due course.

Nominations are invited for election to the Council. Forms can be obtained from the Executive Secretary. These should be completed and returned not later than **1 July 1983.**

Should the number of nominations exceed the number of vacancies, election will be by postal ballot. Voting papers will then be prepared and circulated to all members.

Symposium

A one-day meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London SW8 1SZ, on **5 October 1983,** 9.30 a.m. to 5.00 p.m.

Theme: **FUTURE PLANETARY MISSIONS**

The provisional programme is as follows:

A. 1. A Survey of European Space Agency Planetary Mission Planning
by G. P. Haskell

2. The Mariner Mark II Program
Speaker to be announced

B. Summaries of Scientific Objectives in the Study of:

1. Planetary Bodies
by Prof. K. Runcorn

2. Planetary Atmospheres
by Dr. G. Hunt

3. Small Bodies
by Dr. D. Hughes

C. 1. Launcher Capabilities and Missions Opportunities
by R. Buckland

2. Manned Planetary Missions?
by Dr. R. C. Parkinson

3. A Proposed Classification of Motivations for Planetary Exploration
by Sqn. Ldr. T. J. Grant

Offers of further papers are invited. Registration forms and full details of the programme are available from the Executive Secretary.

34th IAF Congress

The 34th Congress of the International Astronautical Federation will be held in Budapest, Hungary on **10–15 October 1983.**

Theme: **COOPERATION IN SPACE**

Members of the Society wishing to present papers are asked to notify Dr. L. R. Shepherd, Chairman of the BIS International Liason Committee at Society HQ as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

Anniversary Dinner

A 50th Anniversary Dinner will be held at Society HQ on Friday **21 October 1983.** See p.331 of this issue for further details.

Society Visit

MOON ROCKS

An evening visit to the City of London Polytechnic to view lunar samples and hear a short lecture will take place on **26 October 1983,** 7.00-8.30 p.m.

The number of places is limited so early application is essential. Registration forms can be obtained from the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ, enclosing a stamped addressed envelope.

LIBRARY

The Library will be open to members from 5.30–7.00 p.m. on the following date:

20 July 1983

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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JBIS

The monthly issues of JBIS cover a wide range of space topics with special issues on ASTRONAUTICS HISTORY; INTERSTELLAR STUDIES and SPACE CHRONICLE.

The contents of the issues following on from those published in the last list (*Spaceflight*, March 1983) are given below.

Members can obtain the 12 copies of JBIS for 1983 for £20.00 ($34.00), postage inclusive. Single copies of the 1982 issues may be purchased at £2.00 each ($4.00).

Orders to: The Executive Secretary, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

January 1983 INFRA-RED ASTRONOMICAL SATELLITE

P. E. Clegg	Scientific Objectives of IRAS
R. C. Van Holtz	The IRAS Project Organization and Mission Operations
H. C. Bevon	The IRAS Ground Station and Operations Control Centre at Chilton
A. Pouw	The IRAS Spacecraft
R. J. Wildeman	The Dutch Scientific Instrument On Board IRAS
W. Irace and D. Rosing	The IRAS Telescope
K. E. Mount	Ground Operations Software at the IRAS Operations Control Centre
G. R. Thomas	IRAS Preliminary Science Analysis at the OCC
J. H. Duxbury	US Data Processing for the IRAS Project

February 1983 SPACE CHRONICLE

N. L. Johnson	Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satallites
U. M. Lovelace and R. L. Wright	A Concept for Global Crop Forecasting
P. R. Moss	The Development of Global Satellite Telecommunications
A. Kenden	Was *Columbia* Photographed by a KH-11?
K. H. Robinett	Is Occupation an Appropriation?
P. D. Maley	Reflection Characteristics of Certain Classes of Soviet Space Objects
A. Kendon	Military Manoeuvres in Synchronous Orbit
G. L. Borrowman	Operation Morning light: Conclusions

March 1983 INTERSTELLAR STUDIES

E. Sheldon and R. H. Giles	Celestial Views from Nonrelativistic and Relativistic Interstellar Spacecraft
E. Sheldon	Evaluation of Characteristic Parameters for Schwarzchild, Extreme Kerr and Hawking Black Holes
R. A. Freitas	Terraforming Mars and Venus using Machine Self-Replicating Systems (SRS)

April 1983 SPACE CHRONICLE

D. Lunan	Nuclear Waste Disposal in Space
C. Peebles	Air-Launched Shuttle Concepts
I. Pryke and A. Stimsom	Report on the AIAA Biennial Space Systems Conference
N. Kidger	Salyut Mission Report
J. S. Griffith	Astronomical Notebook
P. S. Clark	Aspects of the Soviet Photoreconnaissance Satellite Programme
P. S. Clark	Soviet Spacecraft Recoveries

May 1983 INTERSTELLAR STUDIES

M. D. Nussinov and S. V. Lysenko	Space Vacuum Hinders Radiopanspermia
G. L. Matloff and E. Mallove	The Interstellar Solar Sail - Optimization and Further Analysis
D. G. Stephenson	Comets and Interstellar Travel
W. I. McLaughlin	Pathways & Evolution for Man and Machine
A. R. Martin and A. Bond	Is Mankind Unique?
H. D. Froning	Requirements for Rapid Transport to the Further Stars
P. Birch	Orbital Ring Systems and Jacob's Ladder — III

June 1983 SPACE CHRONICLE

M. J. F. Fowler	Life Science Research On-Board Spacelab
P. S. Clark	The Soviet Space Year of 1982
K. H. Robinett	Proprietary Data *vs* NASA's Need to Know
K. T. Wilson	Rangers 3-5: America's First Lunar Landing Attempts
N. Kidger	Salyut Mission Report
P. M. Sargent and B. Derby	Choice of Lunar Materials as Determined by Fabrication Methods

July 1983 INTERSTELLAR STUDIES

Z. Paprotny and J. Lehmann	Interstellar Travel and Communication Bibliography: 1982 Update
M. D. Papagiannis	Search for Extraterrestrial Life
W. S. Bainbridge	Attitudes Towards Interstellar Communication: An Empirical Study
R. B. Cathcart	A Megastructural End to Geological Time
R. Zito	Chain Reactions in a Hydrogen-Antiproton Pile

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SPACEFLIGHT

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По подписке 1983 г.

OUR 50th ANNIVERSARY YEAR

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CONTENTS

338 **To Uranus and Beyond**
Dr. S. J. Kerridge

344 **18th European Space Symposium**

346 **Milestones**

347 **Space Report**

352 **Space at JPL**
Dr. W. I. McLaughlin

356 **News from the Cape**
Gordon Harris

360 **Shuttle Roundup**

370 **John Young: Pt.5**
D. J. Shayler

371 **Space Communications**

373 **Satellite Digest – 166**
R. D. Christy

375 **Book Notices**

377 **38th Annual General Meeting**

378 **Report of the Council**

OPPORTUNITIES GAINED, OR LOST?

A very large building close to our present premises came on the market recently. It was derelict, as was the case with our own HQ building before acquisition, but it had an enormous potential. If we could have developed this as our new HQ it would have placed our Society in the very forefront of Learned Bodies. Unfortunately, we couldn't grasp this opportunity simply because the Society's membership could not sustain it.

This illustrates how the matter of gaining more members affects us all. It decides not only what the Society does *now*, but what it *can* do in the future. It is the key to our future development. A higher membership would allow us to operate on a better cost-reduced basis which would lead, in turn, to lower subscription rates and expanded member facilities. As examples, we could introduce an exhibition area, the Lecture room could be improved or the Library expanded.

We achieve a great deal with the fund-raising we do but, eventually, it comes down to how many members help to shoulder the load.

Our main problem lies in locating those likely to be interested. Whether securing new members proves easy or difficult, all past experience tells us that the most effective way is active promotion by existing members. There is so much they can do to get new members to join, with plenty of scope for some original ideas and ingenuity. Besides direct introductions, new members can be obtained indirectly, e.g. by writing letters or articles which mention the Society to company and trade magazines or to newspapers and similar publications. Authors, budding or otherwise, who mention the Society in their books – especially if they include our address – are a great boon.

Accounts of Society publicity published in *Spaceflight* recently give many other ideas but all underline the importance of personal contact and of giving the Society's address. Without this, much effort can be wasted.

Members then become an effective team which undertakes a great range of activities, all of which continue to enhance both our Society and its many contributions to space flight.

This is a challenge we must all take up. We have plenty of copies of *Spaceflight* and application forms ready. Help us to place them in the right hands.

В журнале не печатается ряд страниц.

COVER

Work is progressing on the World Space Foundation's solar sail project, aiming for a launch towards the middle of this decade (see further news on p.349). The cover shows a test sail in orbit, with the Moon—a possible target—in the distance at bottom left.

World Space Foundation

TO URANUS AND BEYOND*

By S. J. Kerridge

On 24 January 1986 the Voyager 2 spacecraft will sweep to within 82,000 km of the cloud tops of the planet Uranus to obtain our first detailed pictures of this giant outer planet and its rings. Close-ups of the five presently known moons will be transmitted in a journey that will take the radio signals 2¾ hours to reach Earth. The narrow rings will also be probed by the photopolarimeter detecting the light of stars shining through this diffuse necklace encircling the planet.

Introduction

When the two Voyager spacecraft were launched in 1977 they were the relatively austere remnants of the "Grand Tour" designs. Yet the scientific yield has been anything but austere. Voyager 1 made close approaches to Jupiter and volcanic Io, and to Saturn and its unusual moon Titan before heading out of the Solar System. Voyager 2 also flew by Jupiter and Saturn but along a trajectory targeted at Uranus and, thence, to Neptune. Each flyby used the gravitational field of a giant planet to alter the flight path to the next target (Pluto is not in a suitable position).

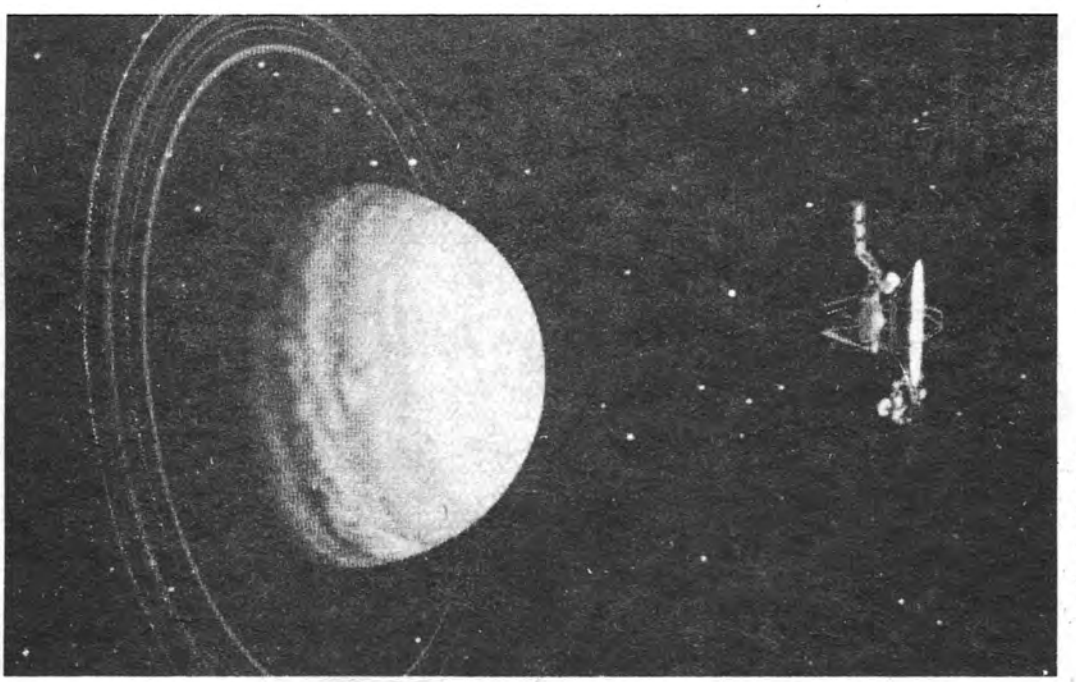
All of the prime mission objectives have been met by the dual spacecraft. In December 1980 approval was obtained from NASA to carry out an extended mission to Uranus called the Voyager Uranus/Interstellar Mission (VUIM) that will support both probes to the end of March 1986. Voyager 1 is presently studying the characteristics of the interplanetary medium and acting in support for its sister craft. Voyager 2 is now in a quiet period using its resources to maintain its health, gathering cruise science data and performing engineering tests essential for the Uranus encounter. These will be vital for obtaining a bountiful harvest of science data on Uranus, its satellites and its rings.

The Target

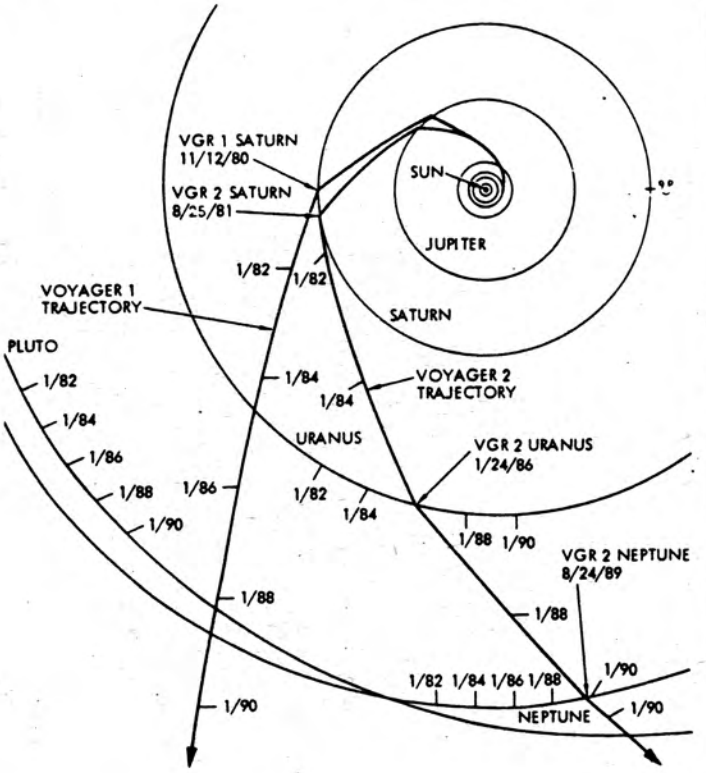
Uranus was discovered on 13 March 1781 by Sir William Herschel. It is located at 19.2 AU (1 AU is the average Earth-Sun distance) from the Sun and has an orbital period of 84.0 years. A unique feature is that its rotation axis is tilted such that, as now, its North Pole can point almost directly toward the Sun. Its effective temperature is estimated to be 58K (−215°C), with there being no evidence for any internal heat source.

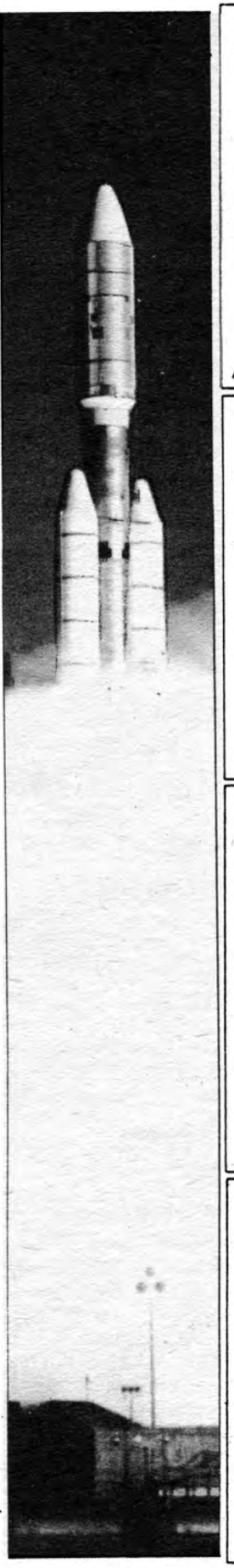
The questions raised before the Jupiter and Saturn encounters apply even more acutely to Uranus because of its remoteness and the lack of any substantial amount of Earth-based data. Is there a magnetic field? If so, what is its strength and orientation? What is the gross morphology of Uranus and its atmospheric com-

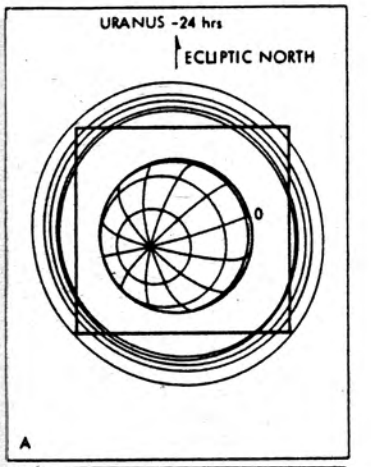
**The full-length version of this article is included in the August 1983 "Space Chronicle" issue of* JBIS. *Dr. Kerridge is with the Jet Propulsion Laboratory in California.*

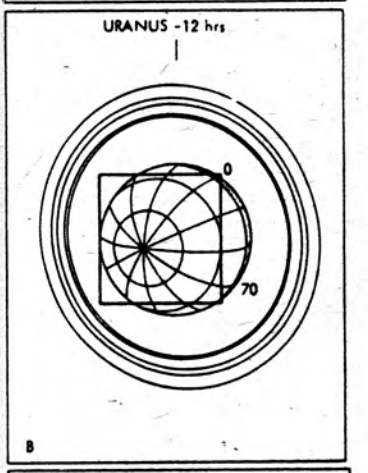


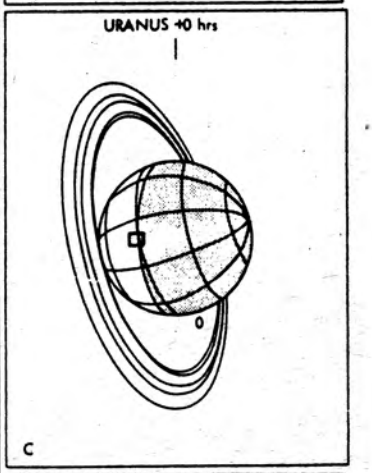
Voyager 2 just two hours before its closest approach to Uranus and its nine narrow rings in 1986. (Computer graphic simulation courtesy of Kohlase and Blinn of NASA/JPL).

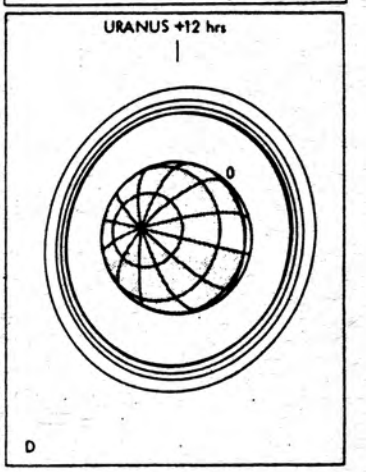












Above: Looking down on the planets from above, with the two Voyagers' routes marked through the Solar System. *Right:* Launch of Voyager in 1977. *Far right:* Voyager's view of Uranus at 12-hourly intervals. The square overlay indicates the wide-angle field of view which is 800 picture elements on a side. The area covered by the narrow-angle camera is some 50 times smaller.

Table 1. Uranus Encounter Characteristics

Event	Time from Uranus C/A† (hr) (hh:mm:ss)	Spacecraft Event Time 1/24/86 (hh:mm:ss)	Distance (km)
20 Uranus radii	- 8:43:30	10:16:30	508000
10 Uranus radii	- 3:57:48	15:02:12	254000
Titania C/A	- 2:46:43	16:13:17	372411
Oberon C/A	- 1:47:02	17:12:58	471418
Ariel C/A	- 1:39:35	17:20:25	140004
Miranda C/A	- 1:07:05	17:42:55	49306
Ring Plane Crossing	- 0:43:04	18:16:56	115197
Uranus C/A	0:00:00	19:00:00	107080
Enter 2.0 ring Sun occ. ‡	+ 1:34:46	20:34:46	141894
Enter 2.0 ring Earth occ.	+ 1:43:41	20:43:41	147737
Exit 1.65 ring Sun occ.	+ 1:52:52	20:52:52	154020
Exit 1.65 ring Earth occ.	+ 2:02:43	21:02:43	161006
Enter Uranus Sun occ.	+ 2:26:48	21:26:48	179037
Enter Uranus Earth occ.	+ 2:38:08	21:38:08	187883
Umbriel C/A	+ 2:51:26	21:51:26	326273
Exit Uranus Sun occ.	+ 3:42:41	22:42:41	241085
10 Uranus radii	+ 3:57:48	22:57:48	254000
Exit Uranus Earth occ.	+ 4:00:11	23:00:11	256053
Enter 1.65 ring Sun occ.	+ 4:16:27	23:16:27	270088
Exit 2.0 ring Sun occ.	+ 4:34:20	23:34:20	285660
Enter 1.65 ring Earth occ.	+ 4:35:09	23:35:09	286371
Exit 2.0 ring Earth occ.	+ 4:53:58	23:53:58	302849
20 Uranus radii	+ 8:43:29	03:43:29*	508000

One-way light time = 2:44:51
* 1/25/86 †C/A = Closest Approach
‡Ring radii are assumed to be within 1.65 to 2.0 Uranus radii

position? What is the structure of its atmosphere and how does it change? What is the rotation period?

There are five known Uranian satellites: Miranda, Ariel, Umbriel, Titania, Oberon (in order of increasing orbital radius). Their radii range from 250 km for Miranda to 815 km for Oberon; these values have been obtained with great difficulty and have considerable uncertainties associated with them. Hopefully, Voyager 2 will give us more accurate values. Orbital periods vary from 1.4 Earth days for Miranda to 13.5 days for Oberon; all five orbits are believed to be almost circular, lying in the Uranian equatorial plane. Questions to be answered include: What are the radii and masses of the satellites? What is the gross morphology of each satellite? What are their surface features? Do any have even trace atmospheres?

The rings of Uranus were discovered in 1977 by the Earth observation of starlight being intercepted by ring material (stellar occultation). At the time they were believed to be the only rings in the Solar System besides those of Saturn; Voyager was to change that by its discovery of a ring system about Jupiter. Now Neptune is the only one of the four giant outer planets without certain evidence for rings.

Altogether there appear to be nine confirmed Uranian rings with radial extents ranging from a few kilometres up to 100 km. They are very dark, reflecting only about 3 percent of light falling on them.

Stellar occultations observed from the Earth are powerful means of seeing the ring structure, exceeding even the camera resolution expected during Voyager close flyby. However, Voyager's passage will enable many significant observations to be made: Are there small satellites either within or near the narrow rings? What is the internal structure? What are the reflection and scattering properties of the ring particles? How do ring properties vary around the planet?

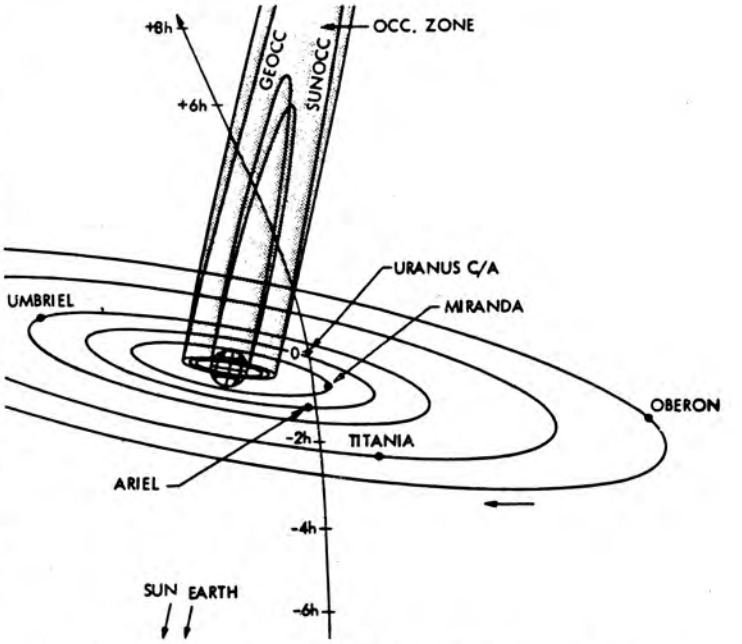
Answering all of these puzzles and others yet to be considered depends on a spacecraft that will have been in transit for 8½ years.

The Spacecraft

The present health of the probe is good, despite some failures. There remains sufficient fuel for manoeuvres and attitude control to satisfy all of the mission objectives and to proceed on to Neptune.

Each Voyager carries 11 experiments. All of them can be used and most are performing to specification. The largest question mark in planning the Uranus encounter regards the use of the Azimuth Scan Platform Actuator. This controls one axis of motion of the Scan Platform with its two cameras. Shortly after Saturn encounter, the actuator stuck and many observations were lost. It was subsequently loosened but many studies are being made to discover the best way of using it at Uranus. An alternate method of pointing the cameras is by rolling the spacecraft. The implications and risks of such a move are being investigated.

Voyager 2 is near the middle of the 4.4 year trip between Saturn and Uranus. Despite the relatively low funding and man-power levels there is considerable planning being carried out to ensure a successful Uranus encounter. This centres on two areas: improving the probe's capability to package and pre-process science data before sending it to Earth; and increasing the size



Looking at the Uranus encounter from a viewpoint directly above the plane of Voyager's path. The "GEOCC" and "SUNOCC" refer to Earth and Sun occultation by the planetary system.

and/or number of ground receiving antennae to allow a high rate of data reception.

It is expected that about 200 images/day will be obtained, compared to about 400/day at Saturn and a peak of about 1100/day during the Jupiter encounter.

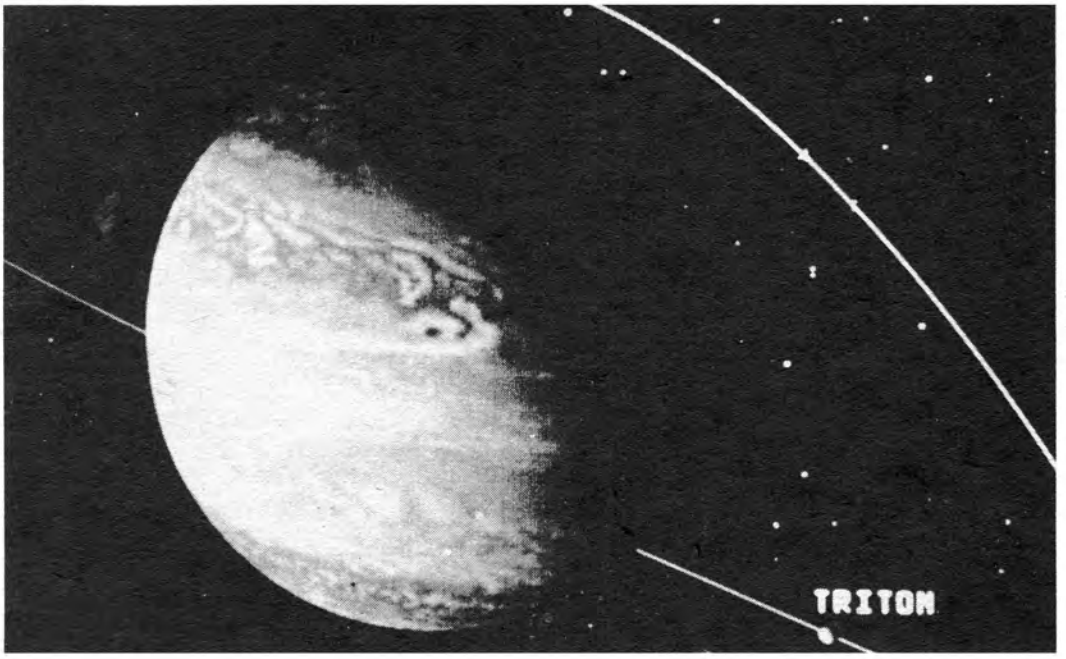
Encounter

After more than 4 years of cruise Voyager 2 will enter the close gravitational field of Uranus on 16 December 1986, 39 days prior to closest approach. For about 30 days before and after closest approach the resolution of the narrow angle camera will be less than 700 km/line pair, the anticipated resolution of Space Telescope. Near closest approach, resolution will be over 30 times sharper than that of Space Telescope.

The orientation of Uranus dictates that the spacecraft will approach the system like an arrow speeding towards a target. This geometry means that the encounter phase will be much shorter than at Jupiter or Saturn. Things are even more difficult because closest approach to most of the satellites occurs near ring plane crossing. At this time Uranus and its rings lie on opposite sides of the spacecraft to most of the satellites. The time required to move the cameras between these equally interesting targets will force compromises in the observation sequences.

Voyager's high velocity with respect to the Uranus system (14.7 km/sec) implies possibly severe smearing of the pictures. Shorter exposure times for the closer satellites will help to reduce the effect and studies are underway for possible solutions.

Voyager must be targeted inside the orbit of Miranda, the innermost of the five moons, in order to slot into the flight path towards Neptune. An earlier plan suggested that the path would approach within 15,000 km



Voyager 2 should fly over Neptune's north pole in August 1989, coming to within 7500 km of the cloud tops. Five hours later the probe will sweep within 44,000 km of Triton. Voyager's path is shown in the diagram as the upper white line.

of Miranda. However, an update in 1982 of the ephemeris of Miranda "moved" the satellite two hours ahead in its orbit, giving rise to a predicted closest approach distance of about 50,000 km for the same trajectory.

Closest approach to Miranda occurs only 25 minutes before ring plane crossing. The moon Ariel is approached to within 140,000 km about 30 minutes before Miranda. The remaining satellites are approached to within 325,000–475,000 km. A search will be carried out for other satellites such as those that might be responsible for maintaining the ring structure around Uranus.

Closest approach to Uranus occurs at a distance of only 107,000 km (compared to distances of 722,000 km at Jupiter and 161,000 km at Saturn), and 43 minutes after ring-plane crossing. The closest pictures will be of the southern hemisphere, a region currently in darkness.

Key science investigations include Earth and solar occultations of the probe by Uranus and its rings. Voyager's radio signals travelling through the rings and the upper levels of the planet's atmosphere will help us to understand their structure. The photopolarimeter will view suitably located stars through the rings to look at the structure with a resolution of a few hundred metres. The ultraviolet spectrometer will observe the Sun through the rings, while direct imaging is expected to be most fruitful after ring-plane crossing because of the anticipated forward-scattering properties of ring particles. Radio occultation will also allow the determination of planetary radius.

Voyager leaves the Uranian gravitational influence on 4 March 1986, 39 days after closest approach, along its trajectory to Neptune.

The Future

On 31 August 1982 NASA approved the continuation of the Voyager mission to Neptune and beyond. Current planning ensures that there will be sufficient propellant and other spacecraft resources to achieve this. By the time Voyager 2 arrives at Neptune on 24 August 1989 it will have been travelling for 12 years.

Neptune is presently the outermost planet of the Solar System, 30 AU from the Sun. Voyager's radio signals will take about 4 hours to reach Earth. This distance means that we need a more extensive ground antenna set-up than at Uranus to ensure a comparable science return. The present plan calls for a close flyby 7500 km over the North Pole of Neptune and a subsequent flyby of its large satellite Triton. Earth occultations by both bodies are unique features of this encounter. There is some evidence that Neptune might have rings, but confirmation *via* stellar occultations over the next few years is of high priority. In any event, a search for or an examination of Neptunian rings will certainly be among the mission's objectives.

Following the encounters with Neptune and Triton Voyager 2 will be travelling out of the Solar System. Both Voyagers will continue to probe the interplanetary medium, to help us understand the distant effects of the solar wind, observe solar magnetic field reversal and search for low-energy cosmic rays, among other experiments. Both spacecraft will seek to discover where the heliopause boundary lays and, thence, exit into interstellar space. If a comet swarm exists at approximately 1 light year (9×10^{12} km) from the Sun, the deceased probes will reach it in about 20,000 years. This is only a quarter of the distance to the nearest star. Yet the small steps of Voyager will yield giant rewards in mankind's search for understanding.

Acknowledgements

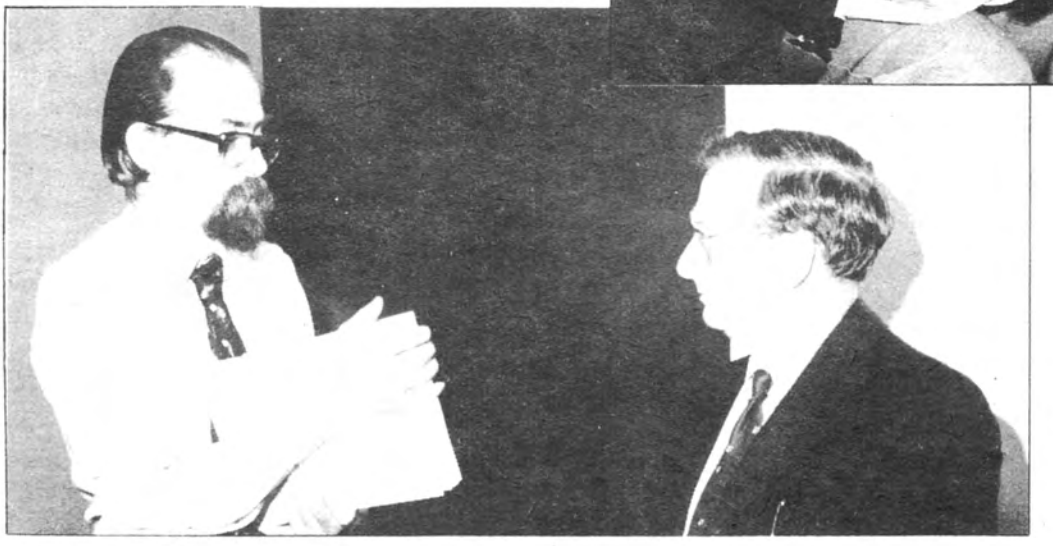
The author wishes to thank C. E. Kohlhase and J. Blinn for their help with illustrations for this article. The Voyager Project is being carried out for the National Aeronautics and Space Administration by the Jet Propulsion Laboratory of the California Institute of Technology under Contract NAS7-918.

18th EUROPEAN SPACE SYMPOSIUM

The BIS played host to the 18th European Space Symposium, with the theme of "Space Programmes for Europe" on 8–9 June at its HQ in London. The conference room was packed to maximum capacity to hear a host of papers presented on the possibilities for the European space industry. Here are a few photographs to give the "flavour" of the event.

Dr. D. J. Shapland of ESA (right) and Len Carter admire a model of ESA's Ariane launcher. Just a week later, on 17 June, Ariane L6 completed a successful launch with the ECS communications satellites.

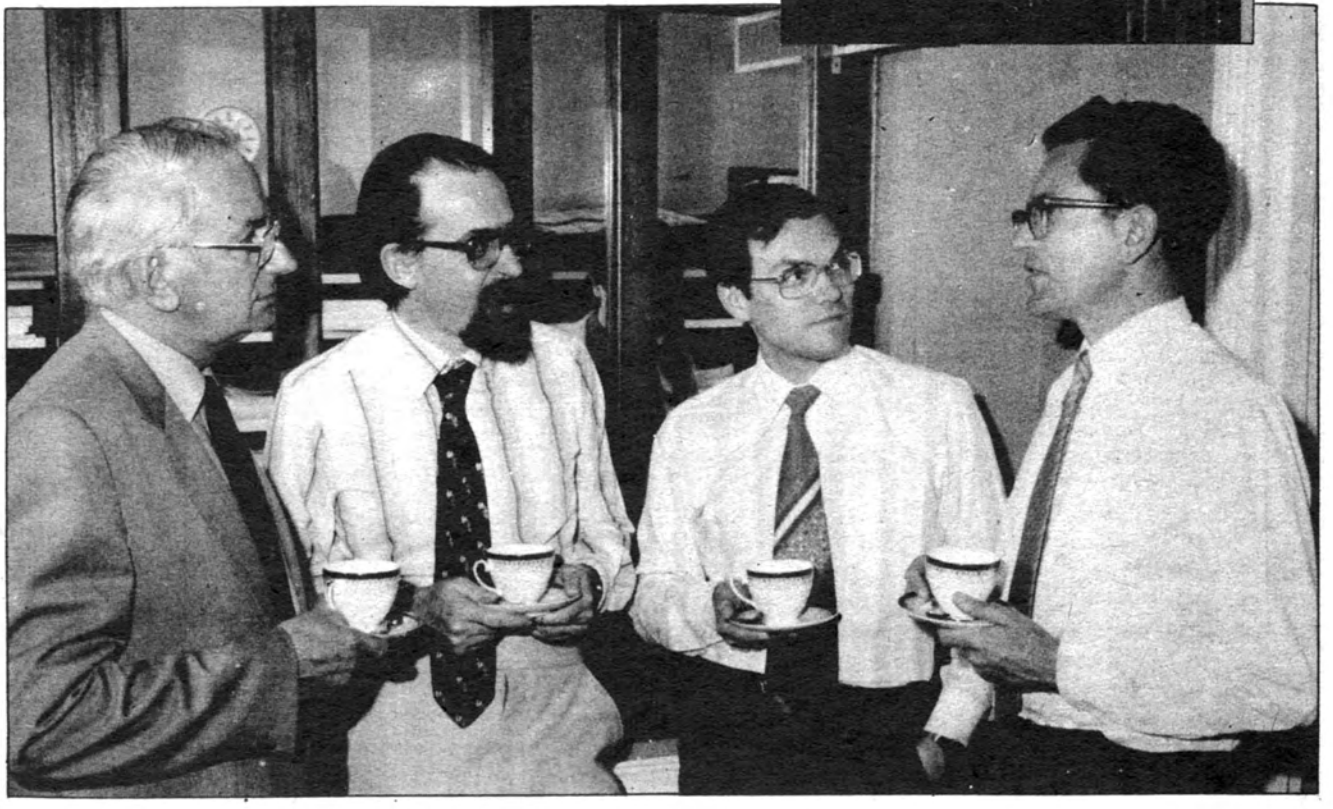
Les Shepherd relaxes between sessions. Dr. Shepherd, a BIS Council Member, has been appointed Chairman of the newly-created Space Energy, Power & Propulsion Committee of the IAF, which has absorbed the former IAA Committee on Energy & Space. BIS Fellow Roy Gibson takes the Chair of the Administrative Committee on Activities and Membership. We also congratulate Roy on being chosen as the recipient for the Allan D. Emil Memorial Award for 1983.



Tony Lawton (right), the Society's President, and Dr. Bob Parkinson, one of the speakers, discuss the progress of the meeting.

Les Shepherd (left) and Peter Bainum take time off for a chat in the Reception Room (or could it be that Peter is admiring Les' Society tie?).

Right: Marcel Toussaint of Eurospace presented a paper on "Future Prospects in Space as Envisaged by a European Space Forum". *Below*: from left, Ivor Franklin and Bob Parkinson (British Aerospace), W. G. Grenham (RAE) and David Fearn. Dr. Parkinson, with Mark Hempsell, presented the paper "The Potential Market for a Low Cost Launch Vehicle". Many papers presented at the symposium will be published in Space Technology issues of *JBIS*.



MILESTONES

May 1983

24 It is announced that a planet—some 5 to 20 times larger than Jupiter—has been observed circling the young star T Tauri, the first time that an extra-solar planet has been directly seen.

20 The Intelsat V (F-6) geostationary communications satellite is launched by Atlas Centaur from Cape Canaveral. It will operate as Intelsat's main Atlantlic Ocean relay, with a basic 12,000 simultaneous telephone call and two TV channel capacity. It can also carry maritime communications for Inmarsat.

26 ESA's Exosat X-ray satellite is launched by Delta 3914 from California at 15.18 GMT into the planned 340 X 192,00 km 72.5 orbit. The experiments will be switched on during the 29th.

June 1983

2 The Soviet Venera 15 probe is launched, believed to be carrying a radar mapping instrument, for a Venus encounter in October. Venera 16 is launched 16 June.

13 The military STS-10 mission is cancelled because the cause of he IUS failure on STS-6 has still not been found. There is little time to find another payload and the crew might be reassigned to a later mission.

16 Ariane L6 successfully lauches the ECS 1 communications satellite and the Amsat P3B amateur satellite from South America at 11.59 GMT. The L7 launch is set for 15 September.

18 STS-7 is launched from Kennedy Space Center. The Anik satellite is released the same day; Palapa a day later, *Challenger* lands in California on the 24th, because of poor weather at KSC.

20 It is reported that the Soviets are offering their Proton rocket as a commercial launcher to Inmarsat, in competition with Ariane, Delta, Titan. Atlas Centaur and the Shuttle.

27 Soyuz T-9 with Vladimir Lyakhov (ex-Soyuz 32) and Aleksandr Aleksandrov is launched at 9.12 GMT to dock with Salyut 7/Kosmos 1443 the next day at 10.46 GMT.

29 TDRS-1, the large communications satellite left in a low orbit after launch from STS-6, reaches its goestationary orbit, having use 370 kg of propellant. Enough remains for a 10 year operating life, The IUS upper stage is now thought to have failed because a cushion around the second stage nozzle lost pressure, leaving the stage without steering.

29 The IRAS infrared satellite discovers its third comet, to be known as Comet IRAS2, at a magnitude of +16.5. The comet is presently heading towards the Sun, with a perihelion between the orbit of Earth and Mars.

DO YOU KNOW?

Attempting to mend a flat tyre in the desert? Not really. Can you identify what the strange-looking object is, and its intended destination? The desert should give you a clue.

Answer: It is a test model of a lightweight landing capsule for the planet Mars. This 1968, pre-Viking 29 kg lander had been sterilized by intense heat, dropped from 80 m up and yet *still* worked after hitting the ground at 130 km/hr (80 mph).

DO YOU REMEMBER?

25 Years Ago . . .

17 August 1958. The Pioneer Thor-Able lunar probe is destroyed 77 seconds after launch.

1 October 1958. NASA officially comes into being, replacing the National Advisory Committee on Aeronautics.

20 Years Ago . . .

30 August 1963. NASA gives approval to the Lunar Orbiter programme.

26 September 1963. The first TV pictures are relayed by the Syncom 2 communications satellite.

15 Years ago . . .

15 September 1968. The Soviet Zond 5 craft is launched, passes by the Moon on the 18th and returns to Earth on 21st.

11 October 1968. Apollo 7, the first manned flight of the series, is launched on its 7-day mission with astronauts Schirra, Eisele and Cunningham aboard.

10 Years Ago . . .

16 August 1973. NASA selects Martin-Marrietta to design and build the Shuttle's External Tank.

13 October 1973. The BIS celebrates its 40th anniversary.

5 Years Ago . . .

28 August 1978. NASA says there is only a 50/50 chance of launching the first Shuttle into orbit by September 1979.

20 September 1978. Salyut 6 cosmonauts break the space endurance record of 96.42 days.

D. J. SHAYLER

SPACE REPORT

SATURN'S THUNDERSTORMS

The planet Saturn has thunderstorms like those of Earth, only much larger, scientists re-analysing Voyager data have discovered. About one week on either side of the two Voyager encounters with Saturn (November 1980 for Voyager 1 and August 1981 for Voyager 2), a very unusual type of signal was detected by the Planetary Radio Astronomy instrument. The signals came in episodes that persisted for several hours, then vanished for three hours only to return again and repeat the pattern. Even though the resemblance to thunderstorm static was recognised at the time, the first scientists to work on the data concluded that the strange signals came from an exotic object undergoing electrical discharging in the middle of Saturn's rings. The waxing and waning of the signals was thought to be related to the object revolving around Saturn.

When NASA scientists reanalysed the data recently, they realized that the overall pattern of signals was inconsistent with an object in the rings. Moreover, they were able to rule out a single isolated thunderstorm in Saturn's cloud tops as the culprit.

Instead, they found that the radio static came from a massive storm complex spread some 64,000 km around the planet's equator.

However, thick haze overlying much of Saturn prevents observation of features in the cloud tops, so re-examination of the thousands of photographs taken by the Voyagers might not reveal this storm.

There is hope that this same radio static detected by the Voyagers can be picked up by large ground-based radio telescopes; efforts are underway in New Mexico, France and Chile.

With this discovery, Saturn becomes the fourth planet to show thunderstorm features, joining the Earth, Venus and Jupiter. However, none of the storms on these other planets can rival Saturn's in size.

NEW ASTRONAUTS

NASA will begin looking for a set of 12 new astronauts – divided equally between pilots and mission specialists – this autumn in what will be the first stage of an annual recruitment drive. Applications are requested from civilians between 1 October and 1 December, while the military have already been screening likely candidates from their own records. NASA's selections will be made next spring with training beginning in the summer.

The number of Shuttle flights and the size of each crew – now at least four – means that there will be increasing pressure on the astronaut corps to cope with the training demands. A factor affecting later selections will be the number of astronauts retiring from service. John Young – due to make his sixth trip into space with STS-9/Spacelab – is the most experienced man serving, having been selected as a Group 2 astronaut in 1962.

ATMOSPHERIC MANOEUVRES

An experiment that saw its first flight aboard *Challenger* in April will make repeated trips into space over the next few years. Called HIRAP, for High Resolution Accelerometer Package, the experiment measures accelerations caused by the thin air acting on the Orbiter during the high altitude portion (above 75 km) of reentry. Engineers will use the information to discover how the Shuttle handles in the rarefied upper atmosphere; aerodynamic flight at these altitudes cannot be simulated in wind tunnels.

The results will be important for the development of reusable orbital transfer vehicles. These vehicles are planned to carry payloads from the Shuttle's low orbit to geosynchronous orbit, and return for reuse. Upon return, these vehicles might use aerodynamic manoeuvring in the upper atmosphere for braking, to place them back into lower orbits for rendezvous with the Shuttle and return to Earth. This manoeuvring will take place in the same altitude range as that being investigated by HIRAP.

ASAT TESTS

Live firing tests of a US anti-satellite weapon were scheduled to begin this summer, although the solid propellant SRAM and Altair motors will not carry the Vought miniature homing vehicle until a firing scheduled for October, writes Joel Powell. In early 1984 the complete vehicle will be fired at Avco balloon satellite targets to be launched in pairs on Scout rockets from Wallops Island in Virginia. Captive "component flight testing" with the F-15 launch aircraft has been underway since last December.

NEW GOES SATELLITE

The latest US weather satellite, designed to monitor climatic conditions over the 'States and a vast portion of the Pacific Ocean from Alaska to New Zealand, was 'aunched from Cape Canaveral on 28 April.

GOES—6 is the third in a series of "geostationary operational environmental satellites" built as part of the World Weather Watch project, which includes Japan's GMS and Europe's Meteosat weather satellites.

At the heart of GOES is an instrument that senses the radiant energy (i.e. infrared) produced by the Earth and its clouds. Working round-the-clock, the satellite sends back "pictures" of Earth every 30 minutes.

While its antennae remain fixed and pointed toward Earth, the satellite s body spins at 100 rpm to provide gyroscopic stability. Housed in the spinning portion is the "visible and infrared spin scan radiometer atmospheric sounder"—or VAS for short. As the satellite spins, the VAS builds up an image of Earth and its surrounding atmosphere one scan line at a time. This provides the West-East scan. On each scan, the VAS scan mirror steps 1/100th of a degree, thereby providing a North-South scan. It takes approximately 18 minutes for the 1,800 scans necessary to produce a full-disc image of Earth, in a process similar to the generation of television pictures.

The VAS can also detect vertical and horizontal temperature gradients and moisture distribution from the tops of clouds to the top of the atmosphere. If there are no clouds, the measurements start from the ground level. Conbined with the imagery, the atmospheric soundings produce three-dimensional profiles designed to provide more accurate weather forecasting and storm tracking. The VAS records visible imagery with a resolution of 0.6 mile and infrared imagery of 4.3 miles.

INDIA'S "ROHINI"

On 17 April India took another step forward in its ambitious space programme by orbiting a 41.5 kg Rohini satellite launched aboard a 17 tonne SLV-3 rocket. The satellite's first pass over India was successfully tracked from the Vikram Sarabhai Space Centre for about 11 minutes. Officials of the Indian Space Research Organization in Bangalore said that all systems were functioning normally, writes Gerald Borrowman.

Prime Minister Indira Gandhi watched the launch and congratulated the launch team, saying that it was a matter of pride not only for those working on the project, but also for others in scientific projects all over India. She said that the 800 personnel had done a great job.

Speaking to newsmen, Mrs. Gandhi said that there would be higher investment in space research in the next 10 years. It was not money that counted, but India's effort to solve the major problems faced in areas where either the monsoon was too late or failed. Justifying investments in space research, Mrs. Gandhi compared them to spending money on a child's education. "The results come later," she said.

The red and white four-stage rocket with India's tri-colour flag on the side took the latest Rohini into orbit. The "D-2" satellite, expected to remain in orbit for 100 days, carried a camera capable of picking out features such as water, vegetation, clouds and snow. The SLV-3 carried an improved AS-4 fourth stage which will play a part in India's Augmented Satellite Launch Vehicle in 1984–5.

IRAS PIGGYBACK

When the IRAS satellite was launched on 26 January a small payload piggybacked into a 640 km orbit attached to the second stage of the Delta rocket, writes Joel Powell. PIX II (Plasma Interaction Experiment) investigated the effects of plasma in space on exposed spacecraft components. The 44 kg package was prepared by the NASA Lewis Research Center, with some of the instrumentation provided by the USAF Space Test Program. PIX II was the fifth such payload mounted on a Delta stage since 1969, and was a follow-on to the successful PIX of 1978.

ASTRONAUTS IN UK

During April a whole host of US astronauts visited the UK, writes Dave Shayler.

On 3 April, Apollo 15 astronaut Jim Irwin was a runner in the 26 mile London Marathon. Then, some two weeks later, six astronauts in training for the Spacelab 2 mission in 1985 began a 10 day visit to the University of Birmingham as part of their preparations for the flight.

Karl Henize and Tony England, assigned to the Mission Specialist positions for SL-2, were accompanied by prospective payload specialists Diane Prinz, Loren Acton, John-David Bartoe and George Simon (two of the four will fly). Spacelab 2 will carry an X-Ray telescope developed by the Department of Space Research at the University of Birmingham.

Finally, on May 9th, first-man-on-the-Moon Neil Armstrong presented a lecture at the National Exhibition Centre near Birmingham. He was the guest of honour at the annual dinner of the British Robot Association, attending in his capacity as a director of a US engineering company which has links in the West Midlands.

CAMERA VETERAN

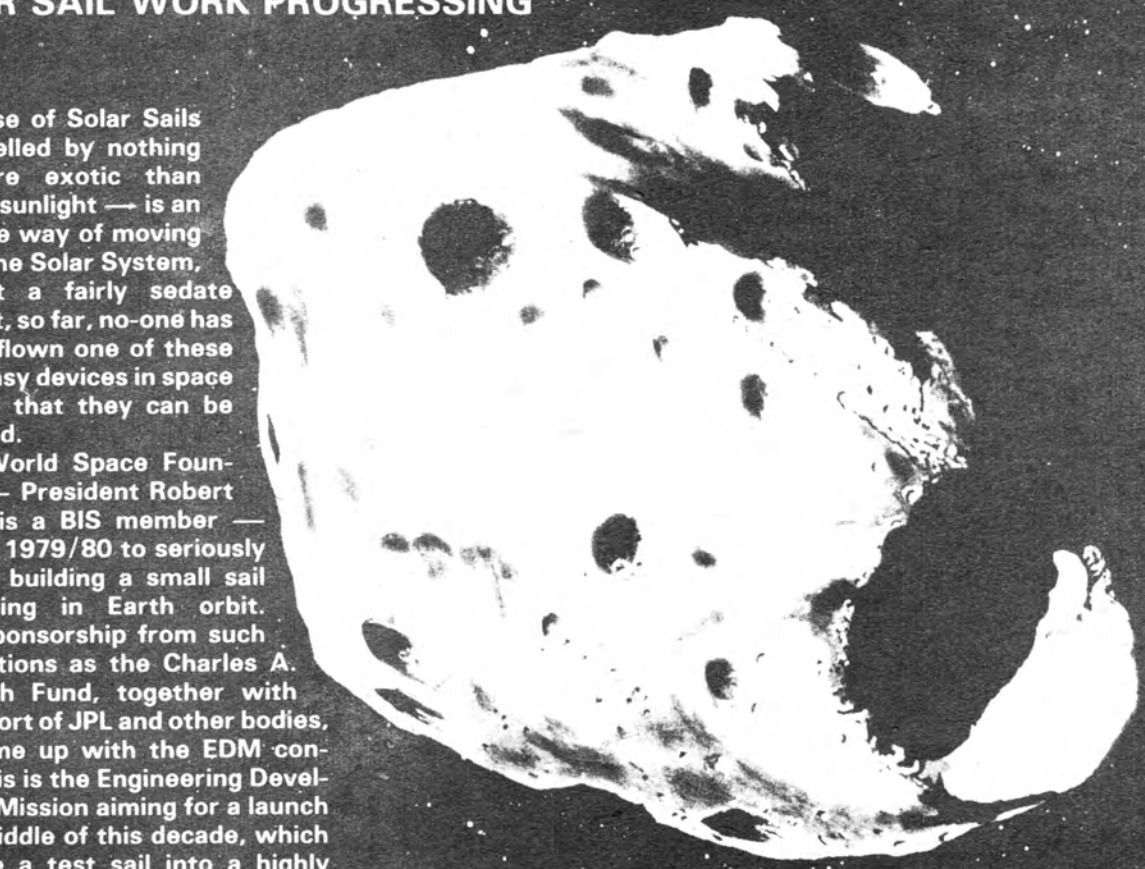
A pioneer of high altitude photography of the Earth died recently in Virginia at the age of 70. Clyde Holliday was responsible for designing and building the cameras for the first captured German V-2 missiles launched by the US Army from White Sands in New Mexico.

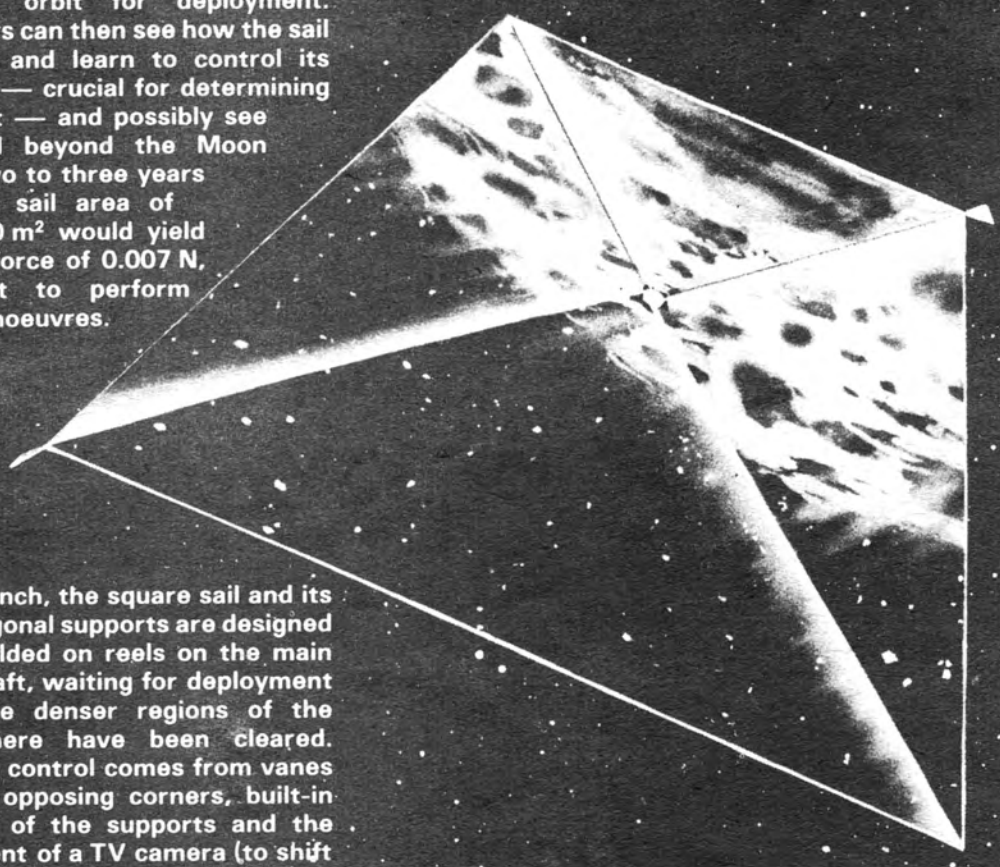
In 1967 he processed the first colour picture of the Earth's full disc (taken from the geostationary orbit, 36,000 km high) and in 1972 he saw "his" far-ultraviolet spectrometer fly to the Moon aboard Apollo 17.

SOLAR SAIL WORK PROGRESSING

The use of Solar Sails — propelled by nothing nor more exotic than plain old sunlight — is an attractive way of moving around the Solar System, albeit at a fairly sedate pace. But, so far, no-one has actually flown one of these large flimsy devices in space to prove that they can be controlled.

The World Space Foundation — President Robert Staehle is a BIS member — began in 1979/80 to seriously consider building a small sail for testing in Earth orbit. Under sponsorship from such organisations as the Charles A. Lindbergh Fund, together with the support of JPL and other bodies, they came up with the EDM concept. This is the Engineering Development Mission aiming for a launch in the middle of this decade, which will take a test sail into a highly elliptical orbit for deployment. Engineers can then see how the sail behaves and learn to control its attitude — crucial for determining the orbit — and possibly see it travel beyond the Moon some two to three years later. A sail area of only 800 m^2 would yield a solar force of 0.007 N, sufficient to perform test manoeuvres.





At launch, the square sail and its four diagonal supports are designed to be folded on reels on the main spacecraft, waiting for deployment once the denser regions of the atmosphere have been cleared. Attitude control comes from vanes on two opposing corners, built-in dihedral of the supports and the movement of a TV camera (to shift the centre of mass).

A prototype, 15 m square and made of 38 cm wide Mylar strips (Kapton is too expensive for these early models!), was deployed in August 1981 and WSF hope to have a full size version ready by the end of this year.

The Hughes Aircraft Co. recently donated an FW-5 solid rocket motor to WSF for use in their project, possibly for taking the EDM into a higher orbit away from the distorting influences of the Earth's atmosphere. Alternatively, the motor might be saved for a later sail mission to a comet or asteroid. The illustration shows a sail (note the two control vanes and the central body) approaching Phobos, one of the moons of Mars.

ULTRAVIOLET TELESCOPE

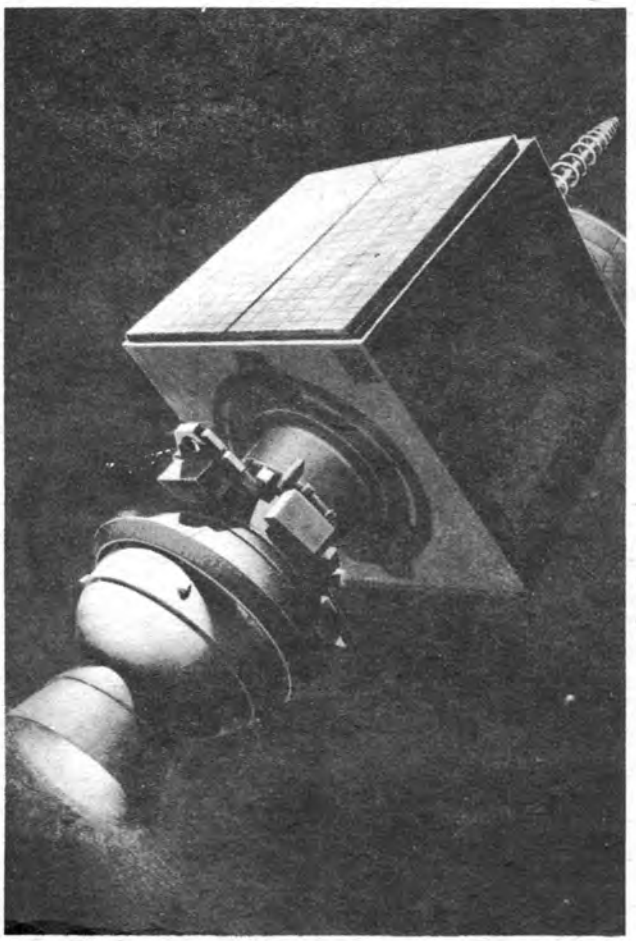
An extreme ultraviolet astronomical telescope is being developed by Johns Hopkins University for use on NASA Spacelab pallets on four Shuttle flights beginning in February 1985, writes Joel Powell. The Hopkins Ultraviolet Telescope (HUT), gathering light at 500–1700 Å, will observe quasars and galaxies and on one flight it will also scrutinise Comet Halley during the 1985–86 apparition.

Optical materials are not transparent to UV radiation below 1000 Å, so coated mirrors will direct the light onto the spectrographic detector of the 112 cm diameter instrument. The Applied Physics Laboratory of the university will build most of the 3m long, 475 kg HUT structure.

PAM FOR GPS

The US Air Force Space Division plans to use 28 Payload Assist Module upper stages to launch their highly accurate NAVSTAR Global Positioning System (GPS) navigation satellites from the Space Shuttle in the late 1980's.

The contract almost doubles the number of PAMs on order, either for Shuttle missions or as a third stage of the Delta launch vehicle. At the time of the decision, 10 PAMs — all carrying commercial communications satellites — had been launched, the last two from the Space Shuttle during STS-5. STS-7 used two more in April.



A Payload Assist Module ignites to take its payload toward geostationary orbit.

The Air Force is interested in using the PAM-DII version, recently announced by the McDonnell Douglas Astronautics Company to handle payloads in the 1590 kg range, with a growth capability up to 1810 kg.

The GPS satellites will provide highly accurate positions — to within 16 m — to anyone with a simple receiver. The measurements will be based on a triangulation of signals from at least three of the satellites, which will be placed into 12-hour circular orbits approximately 20,100 km high.

Altogether, more than 75 firm or potential PAM missions have been identified through the next seven years, with three configurations available.

The Air Force contract brought to 58 the total number of PAMs with firm assignments. Of those, 30 were for civilian missions with either the Shuttle or Delta.

SHUTTLE CAMERAS

The recent dramatic TV pictures of astronauts floating around in the Shuttle cargo bay were made possible by a series of small cameras (weighing only 6½ kg) positioned around the Orbiter. Up to eight of these units can be carried on any one flight, providing coverage of operations inside the cargo bay and showing viewers on Earth what's going on inside the cockpit.

Developed from the RCA units carried by the Apollo astronauts on the Moon, the cameras can be tilted, panned or zoomed by the crew or from mission control in Houston. The cockpit camera is handheld and can be carried anywhere – including the cargo bay – to provide pictures from any position.

RCA provided an initial batch of 20 units under a 1977 contract and has recently received an $11 million order for another 20 to equip the four-Orbiter fleet.

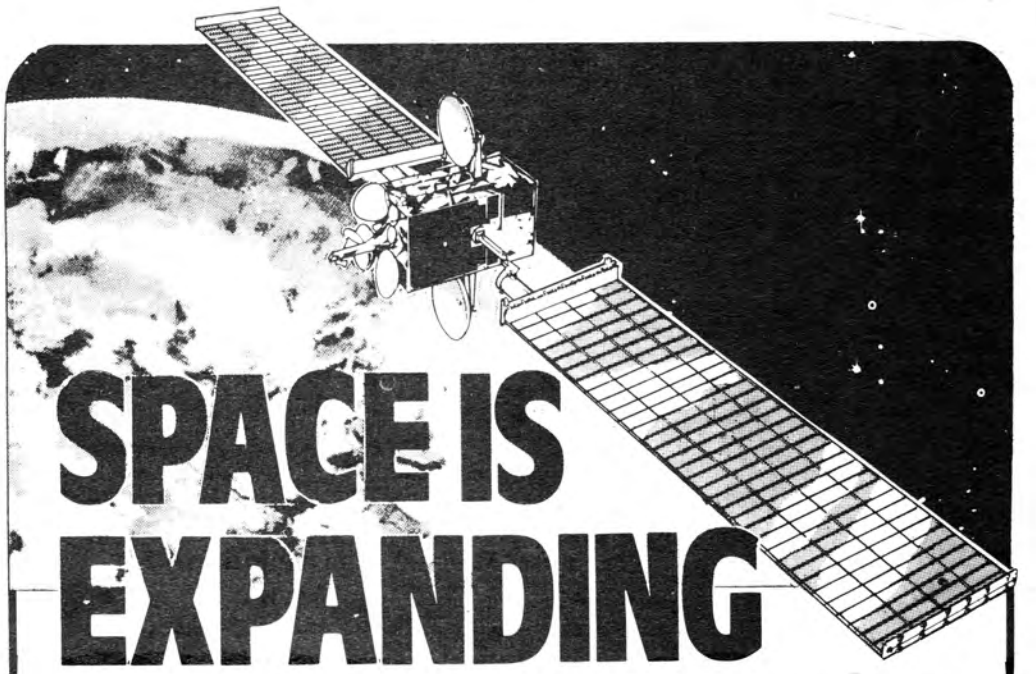
SHUTTLE MARKINGS

The identification marks on NASA's Shuttle Orbiter *Challenger* (OV-099) differ from the first Orbiter *Columbia* (OV-102), writes Dave Shayler.

Looking at *Challenger* on the launch pad in the vertical position, the "USA" designation and the US flag appear on the port wing. On the upper surface of the starboard wing the new NASA logo and the name "Challenger" appear. On *Columbia,* the "USA" marking appeared alone on the right wing, with the flag on the left.

The vehicle's name now appears on either side of the fuselage beneath the cockpit windows. On *Columbia* the name was displayed on the forward sections of each of the payload bay doors which, when open, concealed the name from view. This new position allows the name to be seen during on-orbit operations.

All of the Orbiters will be marked eventually in the new *Challenger* style.



SPACE IS EXPANDING

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SPACE AT JPL

The latest news from Dr. William McLaughlin at the Jet Propulsion Laboratory in California

EXPLORATION CORE PROGRAMME

For the first two decades of planetary exploration technologically difficult and scientifically rewarding missions to the Moon and all of the planets from Mecury to Saturn were accomplished. The skills that were developed during this 'golden age of planetary exploration' are now available to produce missions that do not push the bounds of technology, and hence are of low cost, yet contain meritorious science. The costs can be further reduced by directing the mission and spacecraft design to address specific scientific questions of limited extent—'focussed science'.

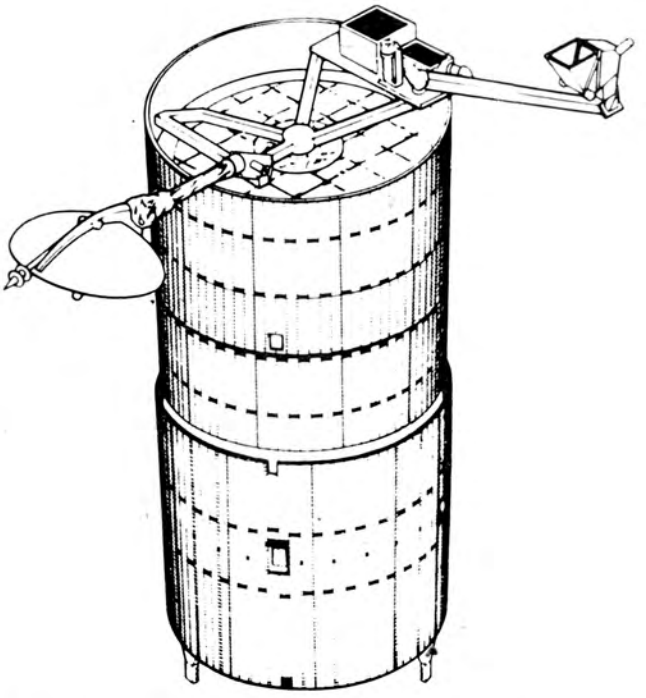
In order to translate these ideas into a plan for action, the Solar System Exploration Committee (SSEC) of the NASA Advisory Council has devised a Core programme of four basic missions plus a methodology to accompany this set. This Core will provide a stable base so that the United States will be able to maintain the capability for planetary exploration. The missions involved have not been approved but are proposed as:

Venus Radar Mapper (VRM)

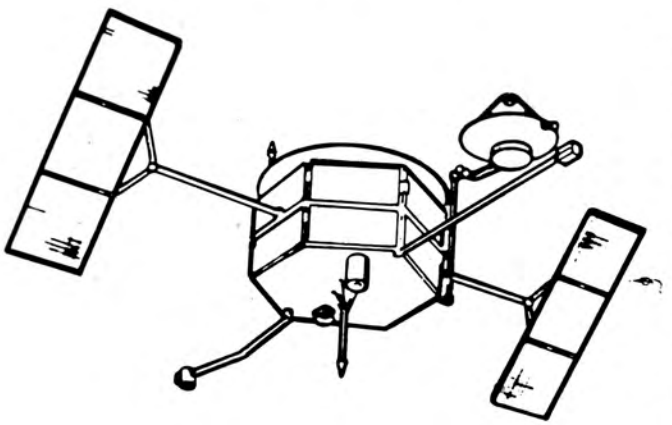
Launch 1988 and data return 1988–1989. VRM (see the July-August 'Space at JPL') uses spare hardware from other missions and with a reduced scope from the originally proposed Venus Orbiting Imaging Radar mission in order to achieve a low-cost exploration of the second planet.

Mars Geoscience/Climatology Orbiter

Launch 1990 and data return 1990–1992. This would be the first in a new class of Planetary Obervers which would explore the inner Solar System using spacecraft that have already been developed for Earth-orbital missions. The two primary objectives would be to determine the global surface composition of Mars and to study the role of water in the martian climate.



A "Planetary Observer" craft based on the successful Hughes HS 376 communications satellite, several of which have been launched from the Space Shuttle. That shown below is based on TRW's Fleetsatcom military satellite; another possibility is RCA's weather satellite series.



Comet Rendezvous/Asteroid Flyby

Launch 1990–1992 and data return 1994–2000. The third mission on the Core programme would be the first to employ the Mariner Mark II spacecraft concept of JPL (see 'Space at JPL' in the September-October 1982 issue). Rendezvous would allow a more leisurely inspection of a comet than will result from the fast flybys of Comet Giacobini-Zinner by NASA's ISEE-3 spacecraft in 1985 and the three Halley missions in 1986.

Titan Probe/Radar Mapper

Launch 1988–1992 and data return 1995–1997. This mission would use a probe derived from the approved Galileo mission to Jupiter along with a flyby or orbiter spacecraft bearing a radar to map the surface of the shrouded, largest satellite of Saturn.

In addition to the four initial Core missions the SSEC has listed candidates for subsequent missions (in alphabetical order):

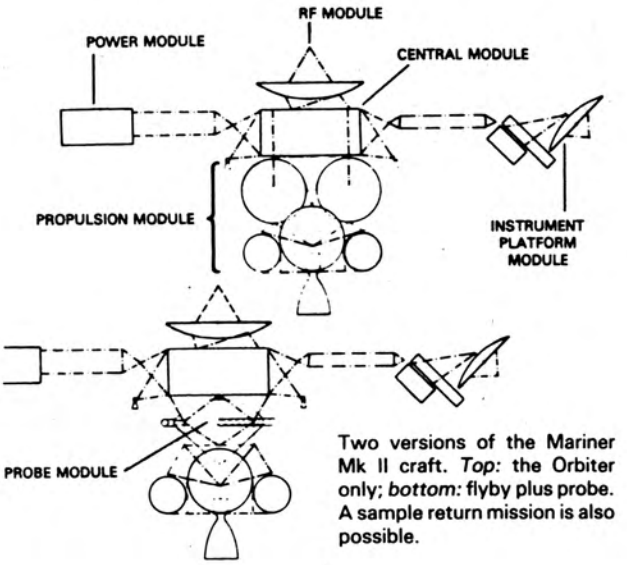
Inner Planets
Lunar Geoscience Orbiter
Mars Aeronomy Orbiter
Mars Surface Probe
Venus Atmospheric Probe

Small Bodies
Comet Atomized Sample Return
Earth-Approaching Asteroid Rendezvous
Multiple Mainbelt Asteroid Orbiter/Flyby

Outer Planets
Saturn Flyby/Probe
Saturn Orbiter
Uranus Flyby-Probe

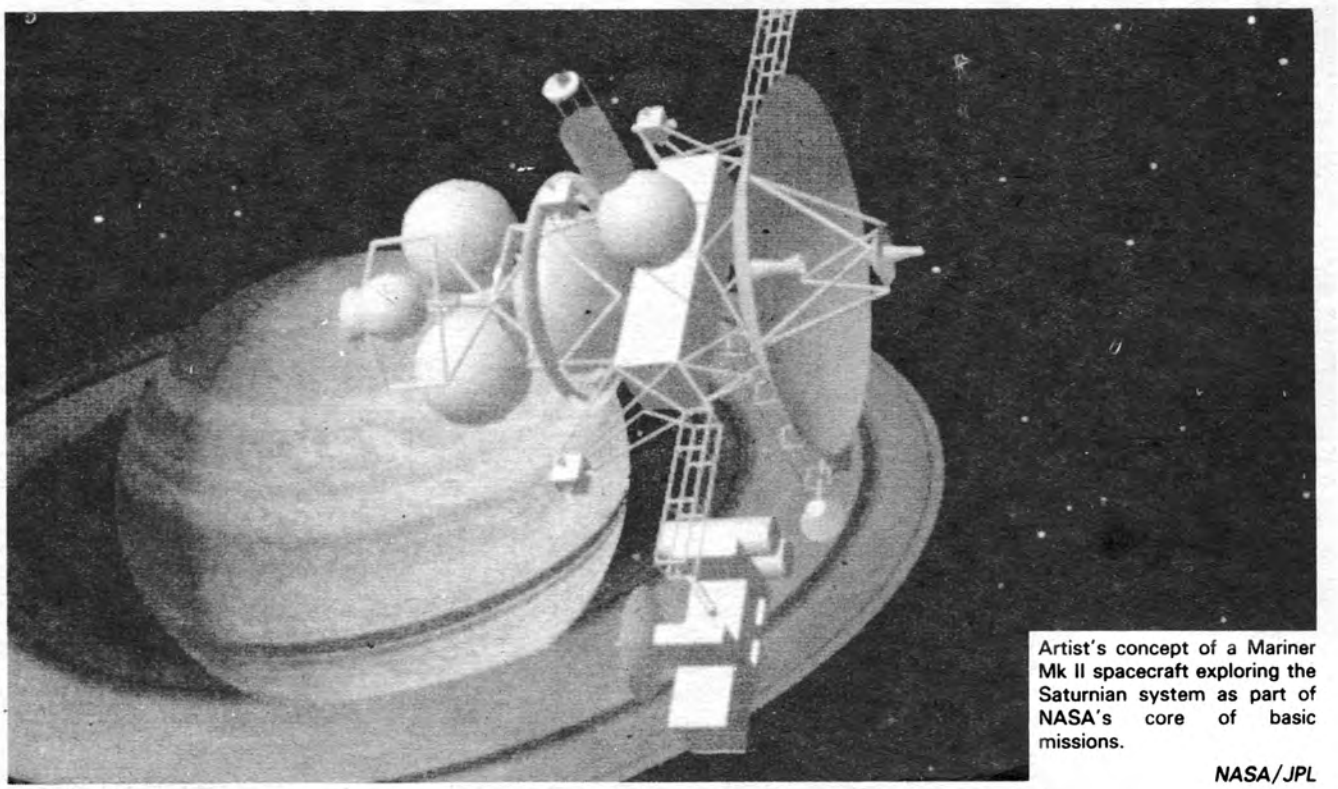
Missions to Neptune and Pluto have been considered by the SSEC and have been assigned high priority but probably will not be flown until early in the next century.

JPL is expected to continue as NASA's major centre for Solar System exploration. It would be responsible for project management, mission operations (including tracking and navigation), and the development of the Mariner Mark II deep-space spacecraft. NASA's Ames Research Center would provide planetary probes, such as the atmospheric probe it is now developing for Galileo, and the Goddard Space Flight Center would supply instrumentation support.



Two versions of the Mariner Mk II craft. *Top:* the Orbiter only; *bottom:* flyby plus probe. A sample return mission is also possible.

The proposed plan for funding would feature a constant level of dollars each year to give further stability to the programme. The amount envisaged is about $300 million per year (as measured in Fiscal Year 1984 dollars) with approximately $100 million going to the Mariner Mark II missions, $60 million to the Planetary Observer missions, and the remainder invested in planetary research and a new multi-mission operations system.



Artist's concept of a Mariner Mk II spacecraft exploring the Saturnian system as part of NASA's core of basic missions.

NASA/JPL

IRAS DISCOVERS TWO COMETS

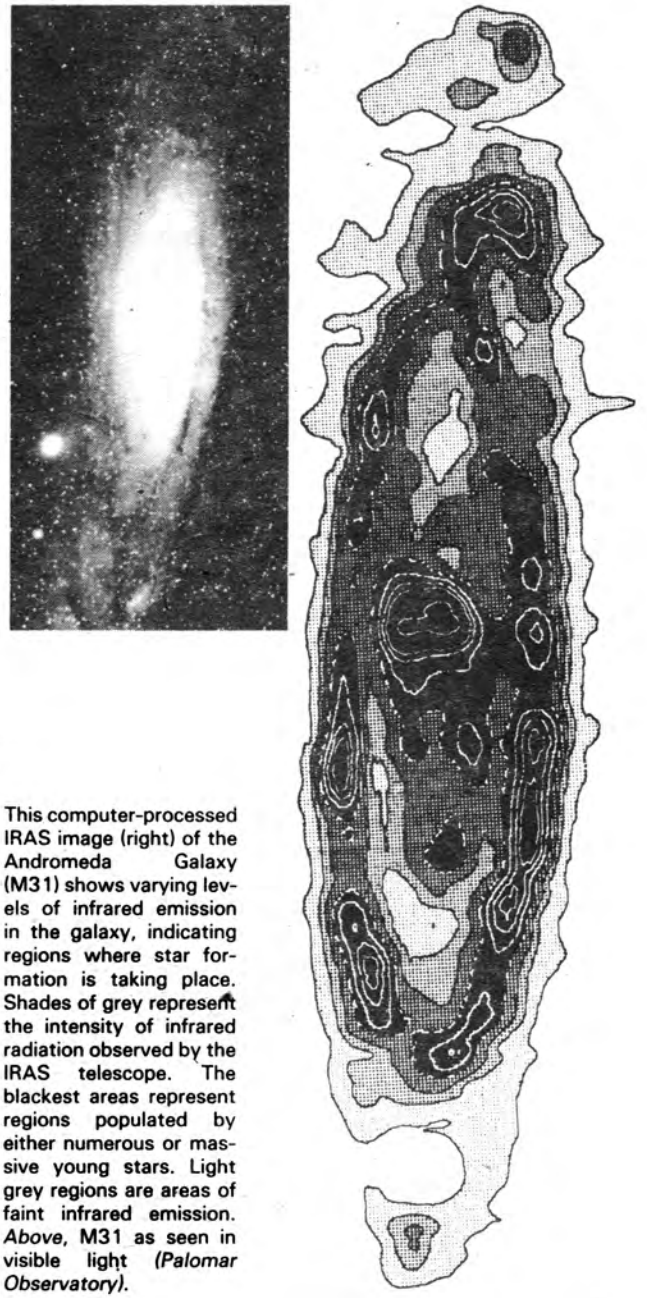
The newly-discovered Comet IRAS-Araki-Alcock (1983d) was independently detected by the Infrared Astronomical Satellite (IRAS) and by two amateur astronomers, Genichi Araki of Japan and G.E.D. Alcock of England. The comet was distinguished by the very close approach it made to Earth, 5 million km on the evening of 11 May, which is the closest approach to Earth of a comet in two centuries. The object made its closest approach to the Sun on 21 May.

The combination of the comet's proximity to the Earth and the availability of infrared observations from IRAS in the 8–120 μm range have made IRAS-Araki-Alcock a scientific bonanza. The comet has also been observed in the visible using Earth-based instrumentation and has been detected in the ultraviolet from a second satellite, the International Ultraviolet Explorer (IUE).

A second, extremely faint, comet (1983f) was discovered two weeks later by IRAS, on 12 May, and confirmed by ground-based observers on 19 May. This comet is one million times fainter than the first and is on its way out of the Solar System, having made its closest approach to the Sun on 20 January 1983.

Astrophysical results fron IRAS include the detection of very young stars (protostars) no more than a million years old. These stars are forming out of two dark clouds of dust and gas known as Barnard 5 and Lynds 1642. As many as five protostars may be forming in Barnard 5 and one or two within Lynds 1642. IRAS has also observed two closely interacting galaxies that are being disrupted by each other's gravitational forces: NGC 1888 and NGC 1889. These galaxies had been studied previously using Earth-based telescopes but were found to be unexpectedly strong emitters of infrared radiation. Scans of the nearby Andromeda Galaxy (M31) have been processed to yield an image and show areas of intense infrared emission, indicative of star formation.

IRAS, launched on 25 January from California, is a joint project among the US, The Netherlands, and the UK with JPL managing the US portion of the effort. Mission operations are being conducted from the Rutherford and Appleton Laboratory in Chilton, England.



This computer-processed IRAS image (right) of the Andromeda Galaxy (M31) shows varying levels of infrared emission in the galaxy, indicating regions where star formation is taking place. Shades of grey represent the intensity of infrared radiation observed by the IRAS telescope. The blackest areas represent regions populated by either numerous or massive young stars. Light grey regions are areas of faint infrared emission. *Above*, M31 as seen in visible light *(Palomar Observatory)*.

MARS PROPELLANT PRODUCTION

The search for ways of reducing the mass of spacecraft has been a continuing theme in astronautics. The objective is to allow the maximum scientific payload to be flown with the available propulsion systems. A well-known technique of mass reduction is simply to throw away parts of the spacecraft structure after they have fulfilled their function. Multistage rockets provide the most familiar example, when fuel tanks are discarded after they have been emptied. A second technique is based upon the replacement of man-made thrusting devices, such as chemical rockets, by environmental forces. Thus, gravity assists from Jupiter and Saturn supplied important shaping of the flight paths for Voyager, momentum transfer from solar photons has been proposed for solar sailing missions, and studies have shown that an atmosphere can be used to slow an interplanetary vehicle and place it in orbit about a planet.

Another class of mass-saving techniques relies upon the discovery and use of chemicals for the spacecrafts' propulsion system in the environment, while the mission is in progress. Bussard's interstellar ramjet would scoop up gas from the interstellar medium and use it for fuel. The Society's Project Daedalus would extract the propellant helium-3 from the atmosphere of Jupiter before a 50-year flight to Barnard's Star.

This month's advanced-concept topic falls in the latter class and is '*in situ* propellant production,' or ISPP as it is labelled by the inevitable acronym. Current

ISPP proposals contemplate placing a lander on Mars with the capability to manufacture oxygen as a propellant for the trip back to Earth. Although no such project has been funded, it has low-cost freatures which make it attractive for future consideration. The idea upon which the technology is based, solid electrolysis, was examined years ago by the German physicist Hermann Nernst (1864–1941), who also formulated the third law of thermodynamics.

A typical mission scenario would involve a descent to the martian surface using techniques similar to those employed by the Viking mission. Once on the surface the lander would engage in its primary activity, collecting 1 kg of Martian surface material, but at the same time it would start using carbon dioxide from the atmosphere to produce oxygen, which it would store. The by-product of this process would be carbon monoxide.

It is estimated that about 10 kg of oxygen could be produced daily by solid electrolysis in the lander's manufacturing plant. Then, after 200 or 300 days of production, enough oxygen would be available to burn the fuel (methane) carried along from Earth to power the spacecraft on its ascent and return to Earth with 1 kg sample. The mass ratio of fuel to oxydizer (methane to oxygen) would only be about one-to-four so that the greatest part of the propellants required for the return journey would have been prepared *in situ*.

In addition to the Mars sample-return mission, the ISPP concept could be applied to sustaining a roving Mars airplane, described in the last issue, or to powering a lander which would 'hop' from place to place to sample and explore varied topographic conditions. It is also possible to feed this manufacturing process with water rather than carbon dioxide as the raw material so that one can speculate on the advantages of ISPP for bodies that contain water; some of the Voyager results suggest that Jupiter's satellite Europa may hold vast oceanic reserves.

Our thanks go to Chauncey W. Uphoff of JPL for discussing ISPP with *Spaceflight*. In addition to the JPL work, ISPP under consideration at Science Applications, Inc. and at the Old Dominion University in Virginia.

LAMENT FOR A LANDER

The last transmission from Viking Lander 1 was received on Earth on 13 November 1982. The Lander (one of two originally placed on Mars in 1976) was to have operated as a scientific station on the Red Planet into the next decade (see 'Space at JPL' in the November 1982 issue) but all attempts to regain contact with it have failed. Several such attempts were made in late 1982 and early 1983.

On 5 May a programme in the Lander's computer should have begun automatic transmissions to Earth. This expectation was based upon a contingency plan built into the Lander's memory which was to have been implemented after not receiving any commands from Earth after a time lapse. Despite use of the 64m antenna at the Goldstone station, engineers of JPL's Deep Space Network were unable to detect any signals. Two further attempts at communication were made on 13 and 20 May when commands were sent from Earth in an effort to get the Lander to switch to different components of its transmitter. Both attempts were unsuccessful.

Despite the termination of all data transmissions from Mars, the feelings of disappointment at JPL were tempered by an appreciation of the enormous amount of data that have been returned by the four Viking craft; the two Landers returned more than 4,500 photos of the Martian surface and the two Orbiters took 51,539 photos. More than one million Martian weather reports were received from Viking Lander 2, and more than two million from Viking Lander 1.

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NEWS FROM THE CAPE

By Gordon L. Harris

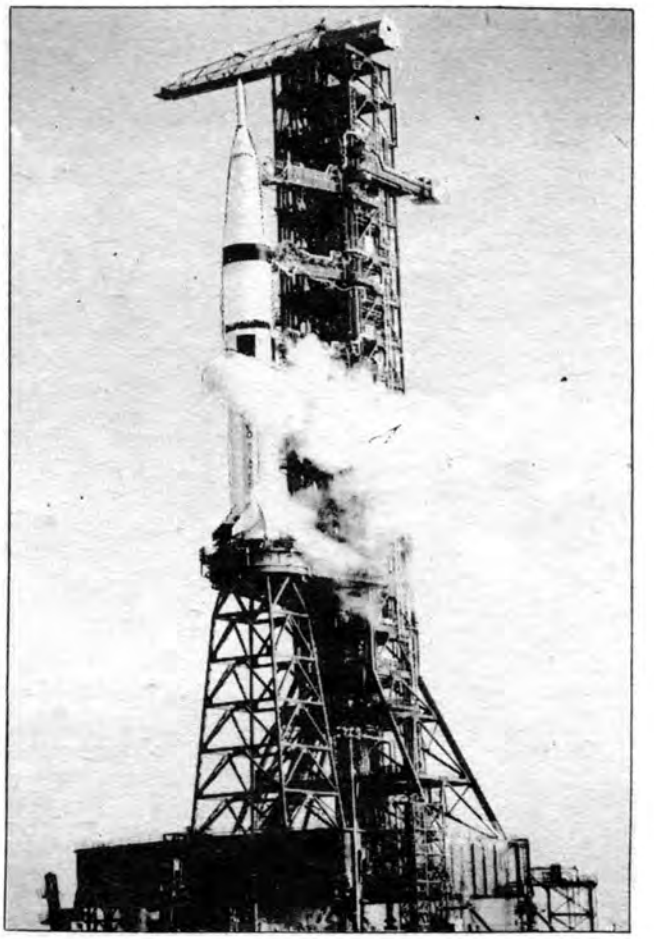
GOODBYE?

The last Launcher Umbilical Tower (used for Apollo 11 and with a "milk stool" pedestal for three manned Skylab launches) is to be torn down. Its removal frees a third mobile launch platform for modifications to accommodate future Shuttles.

NASA has awarded a $567,000 contract to the Best Wrecking Co. to remove the tower. As part of the deal, Best could sell 1800 tonnes of steel valued at $450,000. Not so incidentally, tower and platform cost $34 m in 1965.

Sharp protests have arisen from a group including the National Trust for Historic Preservation, the Council on America's Military Past, Daughters of the American Revolution, the Florida Trust for Historic Preservation and others, wanting to save the tower for posterity.

Political considerations came into focus. The House of Representatives, Science and Technology Committee has authorized NASA to pay Best $1,820,000 in order to take the structure down in such a way that it can be re-erected elsewhere. The funds are part of a $29,120,000 slice in NASA's 1984 purse to modify the launcher platform. No one, so far, has found $8,000,000 more—the estimated cost of putting the pieces back together again like a giant jigsaw. A local Congressman thinks the Smithsonian might pay for it, or that the tower could be erected at the KSC Visitors Center operated by TWA Services, Inc. Presumably he believes the money could come from patrons of the daily bus tours.



The historic Apollo 11 launch tower was also used for the manned Skylab launches after the addition of a "milk stool" to accommodate the smaller Saturn 1B rockets. NASA has now agreed to save the tower, providing free storage at KSC until December 1986. If no plans for its preservation have been devised by then, the agency will have the right to sell it for scrap.

SPACE TELESCOPE PROBLEMS

After six years of work, NASA's ambitious Space Telescope is in serious trouble according to Congressional investigators.

"Program officials admitted they failed to recognize major contractor management deficiencies until significant schedule slippages and cost overruns occurred," says an interim report to the powerful House Committee on Appropriations. Robert Quigly and C.R. Anderson of the surveys and investigations staff promised a final report on 31 July.

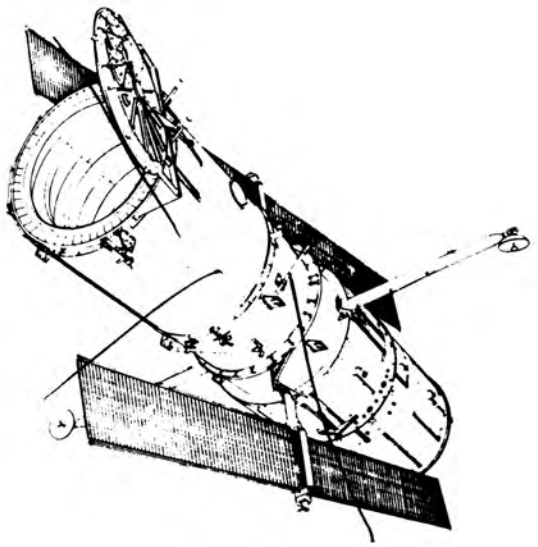
Additionally they concluded there had been a "major underestimation of technical difficulties which caused development cost overruns exceeding $225 million with projections of $20–40 million more in Fiscal Year 1983 and $40–80 million more for FY 1984. The ability to launch in FY 1985 is seriously jeapordized with one senior official advising the chances are "slim to nil".

Perkin-Elmer won the 1977 contract to build the Optical Telescope Assembly, while Lockheed was selected to build the Support Systems Module. The European Space Agency, meanwhile, agreed to provide a Faint Object Camera valued at $50–60 million and Solar Array Panels worth $50 million. NASA's estimated ESA's contribution amounted to 15 percent of the $797.2 million development cost and agreed that ESA should have 15 percent of viewing opportunities.

While the investigators said nothing critical about ESA they did not spare NASA or its contractors, with such comments as: "Initial understaffing to levels 50 percent less than normally allocated to complex programs and lines of communications between MSFC and NASA were described by a senior official as "horrible' at best.'

Perkin-Elmer, the report added: "failed to recognize and properly plan for a project of the technical and manufacturing difficulty of ST and engaged in long-lived 'crisis management' . . . NASA belatedly instituted several actions to rectify management shortfalls, placing 15 persons on site at P-E to devise a management system which will not merely track progress but will control the project. In addition NASA farmed out to others some of Perkin-Elmer's work to permit the company to concentrate on critical problens like Fine Guidance Sensors and Orbital Replacement Unit latches."

The report questioned whether the first, half-completed sensor "even meets the proposed design." A committee representing Lockheed, NASA and Perkin-

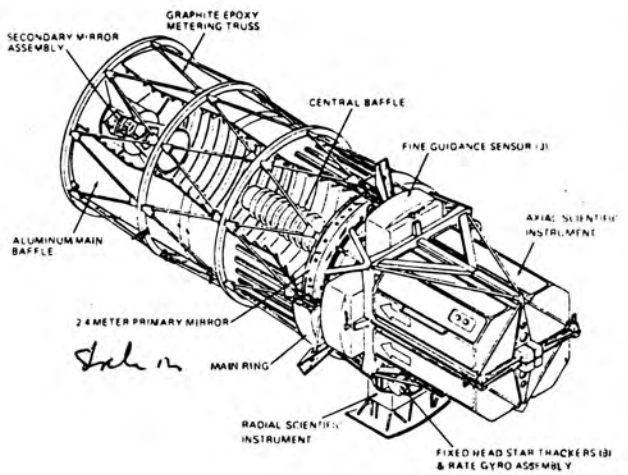


Elmer proposed converting the incomplete unit to an engineering one that could be extensively tested. If NASA accepts this approach a one year delay will ensue, costing $100 million. April 1986 would then become the earliest practicable launch.

As to ORU latches to align and secure scientific instrumentation, three onboard guidance sensors and other devices, the report noted that unless a $5 million quick fix works, NASA is considering taking the latches from Perkin-Elmer and giving the work to Lockheed.

The main telescope mirror had been in a "clean room" for 15 months and investigators found dust accumulations exceeding design specifications. The report observed that "20–30" percent of the mirror's specified performance reflection power is lost due to this contamination. Questions remain as to the need to clean the mirror; if not, what is the expected amount of dust accumulation and reflection degradation over the next several years? If cleaned, how best to carry this out?"

The Committee staff estimated overall development costs will reach $1,000 million while final costs of the entire project "cannot be accurately projected." NASA estimates of $1,297 million extends only through FY 1988 yet the project is supposed to have an operating lifetime of 15 years.



NASA awarded $69.4 million to Perkin-Elmer in FY 1978, while Lockheed received $82.7 million and $76.6 million was allotted for scientific instruments. By now the P-E cost has reached $279.7 million and Lockheed's $263.9 million. Instrumentation has cost $119.1 million. Goddard's assigned functions could result in a $320.8 million budget through FY 1989, the report warned.

The criticisms have lead to a change in personnel at Marshall. Dr. Fred Speer, manager since 1980, has moved to become associate director for science. In his place James Odom from the centre's Shuttle office has been appointed as ST manager.

While Apollo astronauts explored the lunar surface, the concept of a large orbiting telescope evolved within NASA and the scientific community. Six years elapsed before design and operating specifications resulted in October 1977 with contracts for three major components: Optical Telescope Assembly, Support Systems Module, and Scientific Instruments package.

ST will operate in an orbit some 500 km above Earth after deployment by the Shuttle. Scientists believe that its instrumentation will allow examination of objects seven times farther and 50 times dimmer than any Earth based telescope. While the telescope's life span is expected to be 15 years, it must be re-boosted at least every 5 years by a Shuttle. Astronauts would replace any vital components by space walking.

Space Telescope is a multi-purpose satellite weighing approximately 23,000 pounds, measuring 43.5 feet in length and 14 feet in diameter. Within the telescope is an 8-foot diameter mirror and a secondary mirror 1 foot in diameter. Light from a star is reflected and directed to the focal plane, converted into an image which enters the scientific instruments and transmitted to Earth.

BOOSTERS STAY PUT

A plan worked out by the Marshall Space Flight Center in Alabama to move United Space Boosters (builders of the Shuttle boosters) from KSC to unused buildings at Marshall has been turned down by Administrator James Beggs. One factor in the case, and perhaps an influential element, was the militant opposition of Florida's congressional delegation.

MSFC proposed that USBI should move its refurbishment work on used boosters from the Vehicle Assembly Building (where the work interferes with increased Shuttle activity) at a cost of 500 jobs to the KSC community and an increase of that many in Huntsville.

Beggs announced the work would remain "at or near" KSC although a NASA report said a saving of $30 m could be achieved over the next 20 years by going to Alabama. In the background is the likelihood of a long-term USBI contract by which the company would build a $20 m facility at TICO airport, across the Indian River from KSC.

Solid rocket activities now require changes in VAB itself. The work area in two bays will be expanded to accommodate more equipment. New controlled tem-

perature "cure booths" will be installed in Bay 3 to solidify and dry insulation sprayed onto booster nose cones, forward skirts, forward frustums and aft skirts. A building will be provided southwest of VAB for storing processing materials. New cleaning booths and tube bending/cleaning facilities will be installed in Hangar N on the Cape for processing aft skirts.

NASA also recently entered into a $400 million agreement for the motors for STS-7 to STS-15, the refurbishment of boosters flown on the first 10 missions and the tooling to increase production capacity to cope with 24 launches a year.

SHUTTLE PROCESSING

Two teams of aerospace industry giants await NASA's decision for the "largest award of this decade," according to George Skurla, president of Grumman Corp. It is the launch processing contract for Shuttles here and at Vandenberg Air Force Base in California, estimated to be worth more than $2000 million. Thousands of jobs and considerable status are at stake. Proposals were submitted to the Kennedy Space Center on April 29, with the decision expected by mid-August.

Rockwell International, Orbiter manufacturer, who will deliver *Discovery* in September, heads one team. Other members include Martin Marietta, external tank supplier; United Space Boosters, supplier of solid boosters; Boeing Services International, who failed to win the KSC base support contract earlier this year, and United Airlines.

Lockheed leads the competition, teamed with Pan American World Airways; support contractor to the Air Force on the Cape for 25 years; Grumman, whose subsidiary is led by ex-Astronaut Fred Haise (Apollo 13), and Morton Thiokol, manufacturer of the solid booster motors.

While Rockwell would seem to have an edge because its group has prepared the Shuttle so far, Lockheed developed the Orbiter thermal protection system, Grumman supplies Orbiter wings, participates in Shuttle avionics, and furnished a trainer aircraft for the flight crews. Newspaper advertising by Lockheed brought in 7,000 job applications here plus 2,000 more in the Vandenberg area. Rockwell followed up with advertising for its partnership. Local Rockwell employees raised $1,000 and bought radio commercials supporting their employer. None of which, obviously, will influence NASA's selection. The winner will phase into operations here in early 1984 and will conduct the first West Coast launch in 1985.

SPACE CONGRESS

The 20th Annual Space Congress was held at Cocoa Beach (next to the launch site) in late April with most of the 1,300 participants hailing from KSC or Patrick Air Force Base.

Technical papers and briefings during the three-day Congress were shared by DOD, NASA and industry. The space agency provided 48 session organizers, chairmen or briefers while contractors furnished 46. Defense opened the proceedings with a battery of Air Force officers discussing future Shuttle usage.

STS will eventually achieve its specified payload capability of 29,500 kg in equatorial orbit by 1986. By then, main engines will burn at 109 percent rated thrust while high performance solid boosters will be lightened by the use of filament-wound cases. *Discovery*, third of the fleet, should reach KSC this September. The fourth orbiter, *Atlantis*, is due in December 1984. NASA continues to hope for a fifth orbiter depending upon support of the Reagan Administration and Congress.

More development effort will hopefully increase lifetime of main engines: 55 starts is the current goal. Last of heavyweight external tanks will fuel STS-8. White tiles will replace the blanket-type silicon insulation tested on *Challenger* which lost the material during reentry at the end of STS-6. Orbiter 103, *Discovery*, will be tiled before delivery.

William Rock, of the KSC plans office, predicted that Shuttle turn around time will reduce to 28 days by 1986. By 1984 KSC expects to launch 10 Shuttle missions, or twice the planned 1983 schedule.

Among topics discussed were:

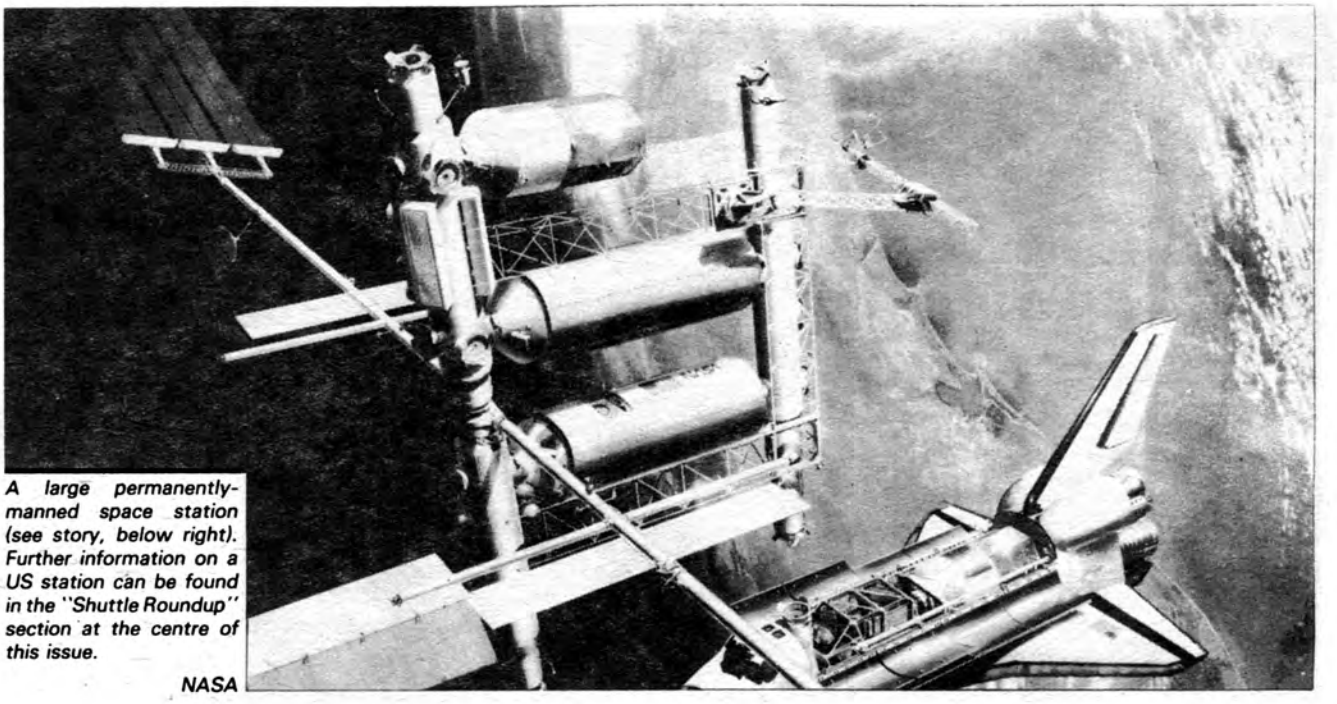
James Hughes of the Marshall Space Flight Center and Thomas R. Mobley of Martin Marietta described and external tank aft cargo carrier which could accept payloads up to 6 m long and 4.5 m in diameter, weighing 7,500 kg.

D. Charhut and W. Ketcham of General Dynamics described new versions of Centaur which would boost NASA and military spacecraft into geosynchronous orbit weighing five tonnes or more.

Frank Williams and Robert Tewell of Martin Marietta talked of "Shuttle Derived Cargo Vehicles", using the

A strange organism from outer space? No, this is silica fibre before being turned into "blankets" used for insulation on the Shuttle instead of the heavier tiles. Some was lost from the OMS pods during STS-6 launch but damage was not severe.

Manville News



A large permanently-manned space station (see story, below right). Further information on a US station can be found in the "Shuttle Roundup" section at the centre of this issue.

NASA

external tank and SRBs, minus Orbiters. Several variations could place up to 110,000 kg in orbit. Touching upon a recent Defense proposal, they said that a larger tank and two solid boosters plus four main engines attached to a payload module could place 18 lasers in orbit with diameters of 8 m or more weighing 68,000 to 110,000 kg.

CENTAUR MODIFICATIONS

Unlike old soldiers who "just fade away," rockets seem to go on forever. Just like Centaur, which NASA solemnly once ruled out in favour of IUS. Centaur is not only back, but KSC now plans to modify pads 39A and B, three mobile launchers, and checkout facilities in the Orbiter Processing Facility to handle it as another upper stage for Shuttles, all at a cost of $6,023,983. Pad 39B will become operational by 1986.

Centaur will be used for the Galileo and International Solar Polar spacecraft, launched within seven days of each other in 1986. Both pads, two mobile launchers and two Shuttles will be required.

STAYING HEALTHY

On the eve of the STS-6 launch in April, NASA announced a policy change tightening the release of information concerning crew health during Shuttle missions. A private medical communication link is now a confidential medical consultation between doctor and patient. However, the commander must report on the open air-ground link, in at least summary form, any crew health situation which might affect the mission impact.

SPACE STATION USES

Eighteen proposals for studies that may lead to "innovative uses" of a future space station have been accepted by NASA. The agency allotted $400,000 for this purpose. Meanwhile, eight industrial studies are investigating the requirements for such a station. Internal agency studies and a scientific advisory committee are assisting planning efforts to define a station.

The 18 selections were culled from 300 proposals. Half the studies will be conducted at universities, a third by the private sector and the rest at government laboratories. The final reports are due in September.

NEW UPPER STAGE

NASA entered into a cooperative agreement on 18 April with Orbital Systems Corp., of Chicago, Illinois, to produce a Transfer Orbit Stage for use with Shuttles. The agency said it will save $30 million in development costs; first use of the stage is anticipated in late 1986.

Martin Marietta in Colorado will build TOS using a solid motor from United Technologies. Weighing 12 tonnes, TOS will be capable of boosting satellites from a 2,700 to 5,900 kg into geostationary orbit. OSC president David Thompson said that TOS will cost users between $16 and 20 million. "We intend to make life as difficult as possible for Ariane," he added.

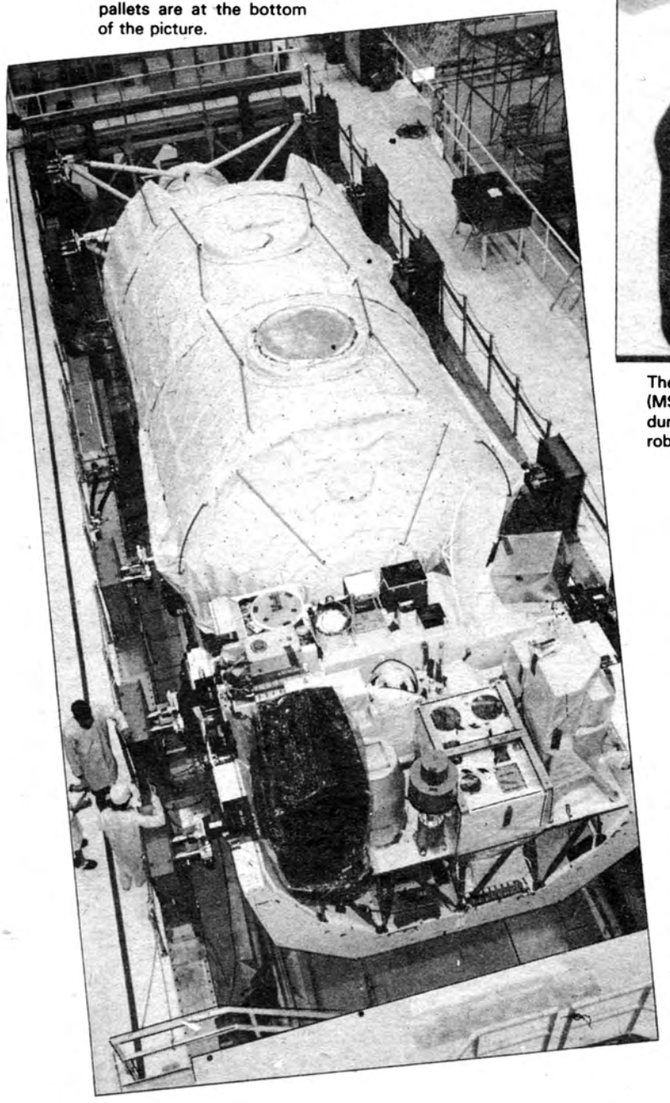
Lt. Gen. James Abrahamson, Shuttle chief, said that NASA's only investment will be technical monitoring and advice from a project office at Marshall Space Flight Center. Upper stages available for use with Shuttle Orbiters will then include IUS, PAM, TOS and Centaur, the latter intended primarily for inter-planetary missions requiring escape velocity.

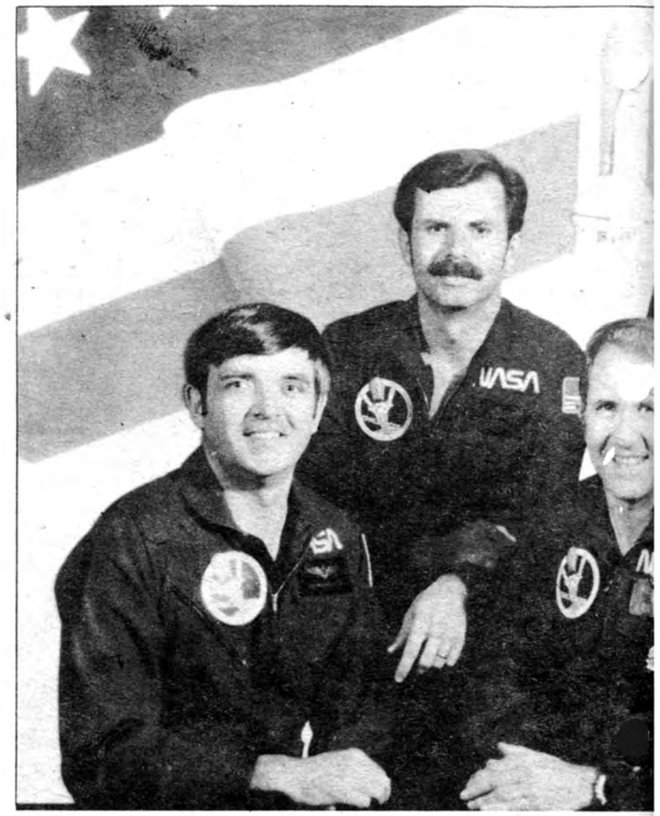
SHUTTLE ROUNDUP

The four Space Shuttle flights planned for this year show that the programme is now on an operational footing. Over the next few pages we include pictures from the recent STS-6 and -7 missions, a look back at that sixth flight by Don Robertson, a photographic look forward to Spacelab/STS-9, the crew biographies for STS-9, a report on the *Enterprise* visit to the UK and, finally, a summary of forthcoming missions.

Regular Shuttle reports are to be found in our usual "Space Report" and 'News from the Cape" sections.

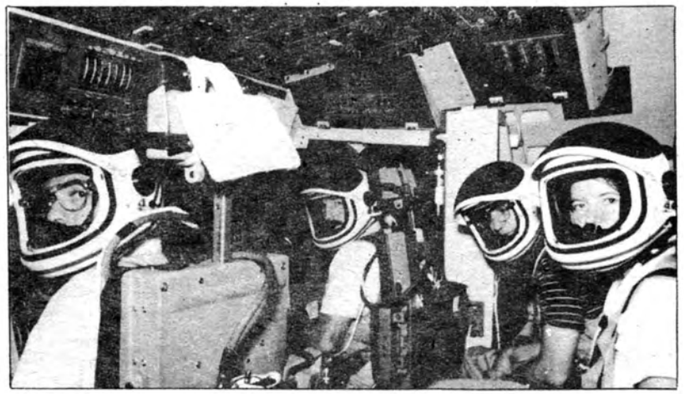
Below: Spacelab 1 nears completion before it is inserted into *Columbia* for the STS-9 mission. The pressurised module is at top (the tunnel leading to the Shuttle airlock is just visible at extreme top); the experiment pallets are at the bottom of the picture.



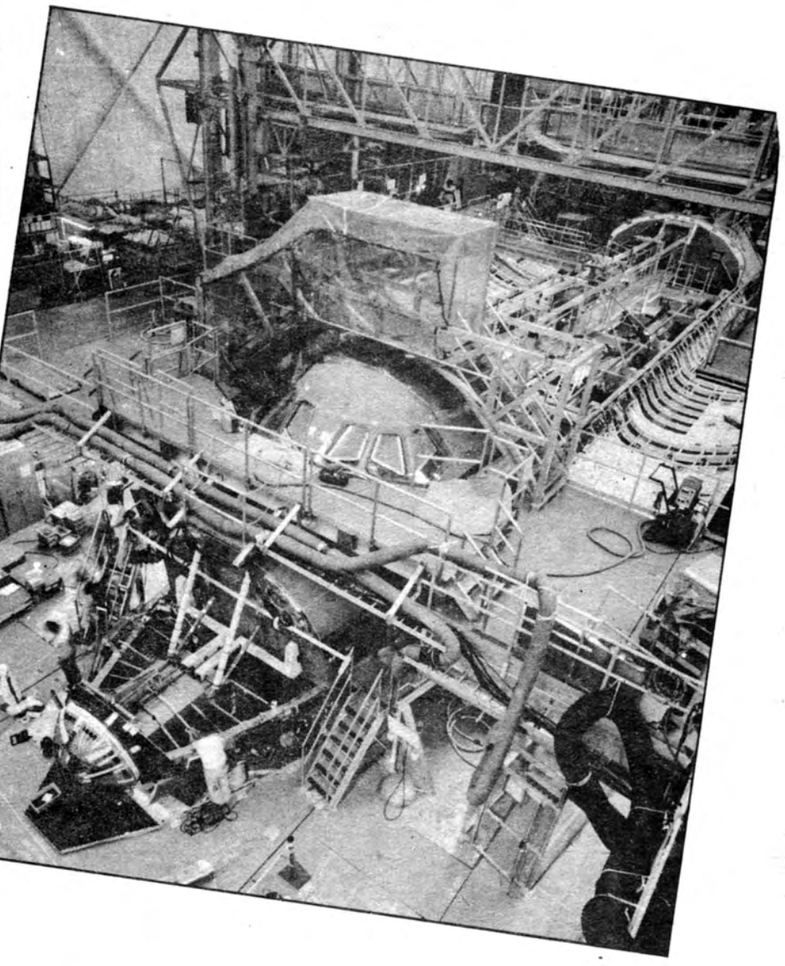


The crew for STS-8. From left: Daniel Brandenstein (Pilot), Dale Gardner (MS) and Guion Bluford (MS). The mission should have carried the second T during STS-6 that plan has now been dropped. Instead, a large test article robot arm's ability to handle large payloads. India's Insat 1B satellite will still

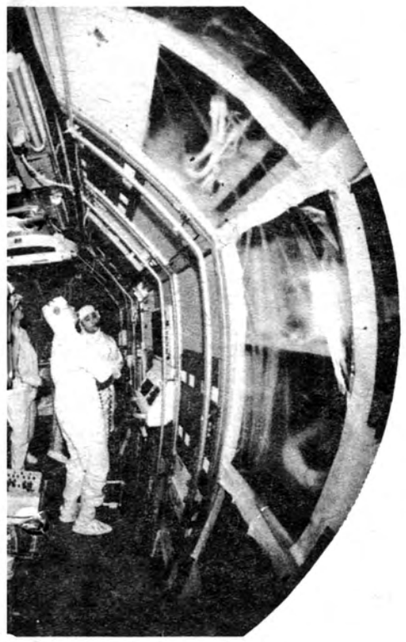
(Mission Specialist), Dick Truly (Commander), Bill Thornton DRS communications satellite but following the IUS failure previously intended for STS-11 will be used to test the go aloft.



Above: the STS-7 crew during simulator training for their recent successful mission. From left: Bob Crippen, Fred Hauck, John Fabian and Sally Ride. Norman Thagard had to sit below in the mid-deck area. Shuttle astronauts have to spend 85% of their simulator work on practising aborts. *Below: Columbia* and *Challenger* will soon be joined by a third Orbiter, *Discovery*, seen here during the final stages of assembly at Rockwell in California. Delivery should be made this autumn; *Atlantis* should join the club by the end of next year.



A fish-eye lens' view showing work underway inside Spacelab 1. At left is Owen Garriott (veteran of Skylab); behind him is Ulf Merbold and at centre is Michael Lampton, backup to scientist Byron Lichtenberg.



ENTERPRISE DROPS IN

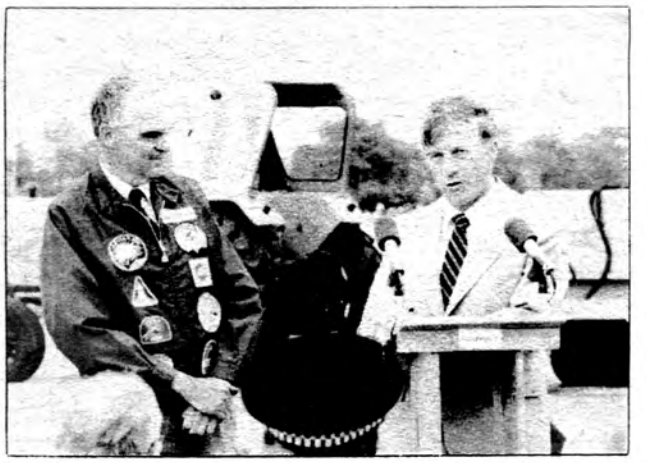
The UK—and Europe in general—was treated to a visitor from the skies during the first days of summer. NASA sent over the world's largest double act to impress visitors and potential customers at the Paris Air Show at the end of May, with stops in Germany, Belgium and London during early June on the return journey.

The first Shuttle Orbiter, *Enterprise*, used for drop tests in 1977/78 and now forever Earthbound, made its European tour as the piggyback partner of NASA's 747 transporter. On Sunday 5 June it headed for London from Brussels, flying along the River Thames just 800 m high to give city-dwellers a good view—including the Royal Family at Windsor Castle—before making tracks for the crowd of "several hundred thousand" waiting at Stansted Airport 50 km away.

Dr. Hans Mark, NASA's Deputy Administrator, was aboard the Jumbo and gave a presentation to an almost exclusively BIS audience the following evening at the US Embassy. He was moved by the previous day's welcome, "Of all receptions we've had in Europe, the one in Britain has exceeded them all."

Dr. Mark sees the next great challenge for NASA as a space station in low Earth orbit, eventually serving as a base for a return to the Moon on a permanent basis around the turn of the century. There was no doubt in his mind that this would be the next logical step to take.

In fact, when basic requirements for a Shuttle were being formulated in 1968 under the direction of NASA Administrator Tom Paine the main thrust was for a dual Shuttle/space station programme. One was viewed as a natural part of the other. The plan, which included a reusable, fly-back Shuttle booster, was turned down by President Nixon on the grounds of cost—$25,000 million—who advised them to return with a half-scale programme.

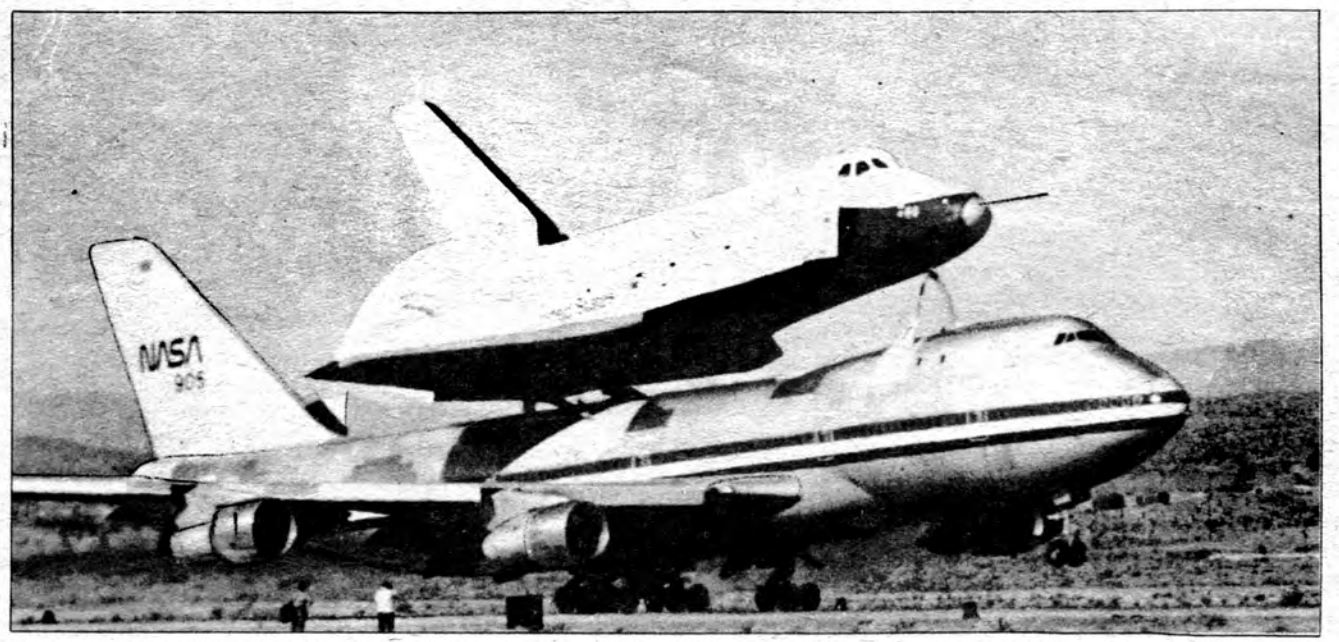


Hans Mark (left), NASA's Deputy Administrator, and STS-6 Commander Paul Weitz address the waiting crowds at Stansted on the 5 June.

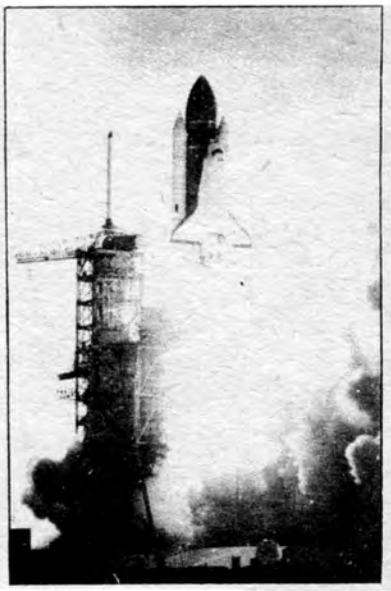
1969 saw the space agency decide on a Shuttle-only path on the premise that a space station would follow automatically. It was also prudent to get the more technically-demanding work out of the way first.

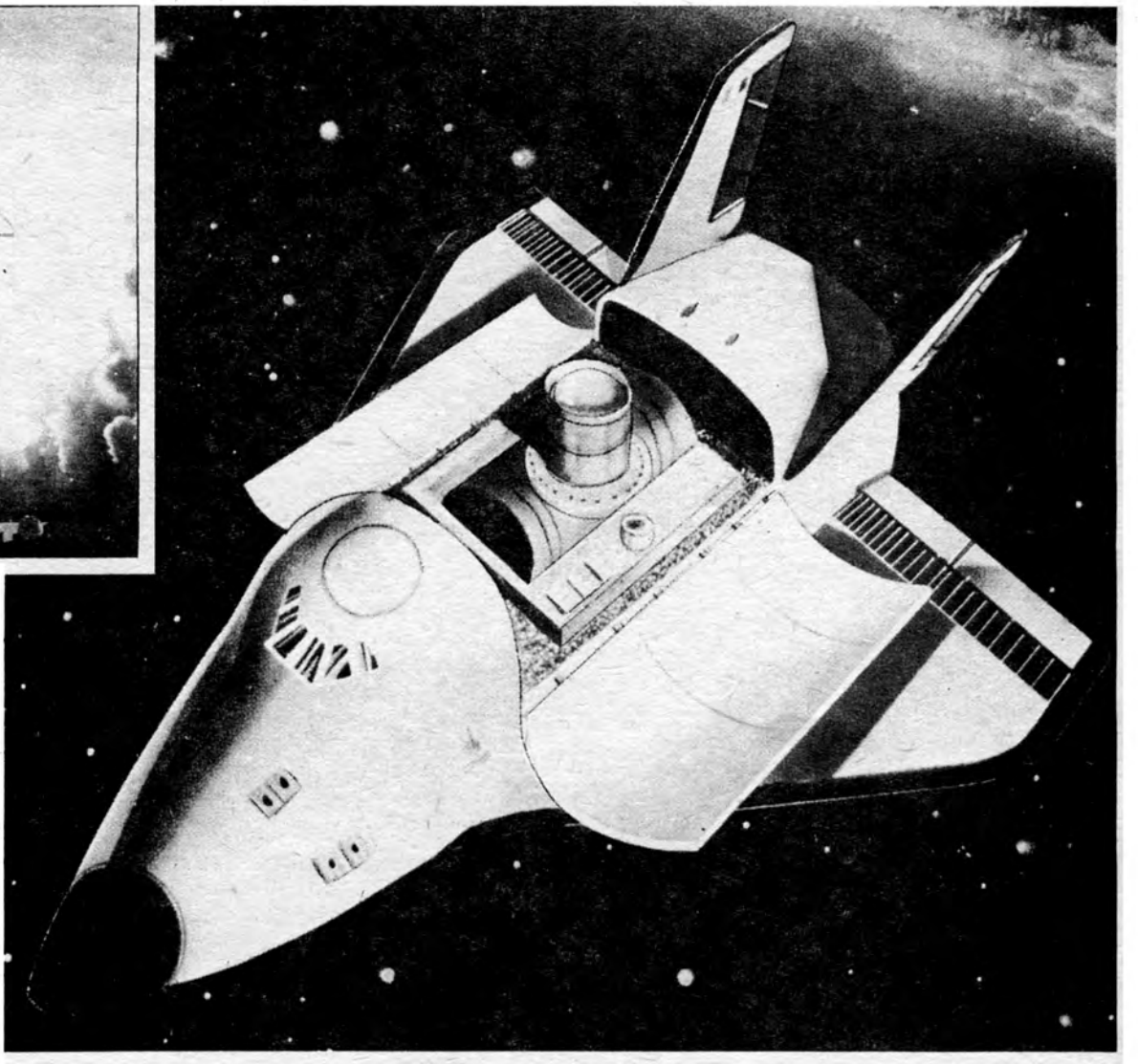
This would seem to be a logical progression but, as Dr. Mark pointed out, the Soviets have approached the problem from the other direction. The Salyut stations have been operating since 1971—although not with complete success—and only now are we beginning to see the development of a Soviet shuttlecraft.

In his view, though, NASA has chosen the better route. The Soviet shuttle is some 6 to 8 years behind



Enterprise and its 747 as they appeared on the European tour (this is a 1977 picture of the gliding drop tests). BIS member Mel Smith writes "The combination made two low passes then came in low over our heads for its final approach. It disappeared behind a grassy knoll to land. We were lucky enough to be able to chat with the 747 flight engineer and he noted that *Enterprise* generated 70 per cent of its own weight in lift. Even so, the Jumbo had to be strengthened to carry the extra weight. I spoke to Paul Weitz and I was well aware of the respect our Society commands. I asked him when his next flight would be. He replied, "I don't know. I never get home to find out!" As a public relations exercise it was a tremendous success."





Above: the launch of STS-7. *Right*: the French "Hermes" Shuttle concept. Could it form part of an international space effort?

its western conterpart and it seems that the US station will prove to be more useful.

But how far along the road are American plans for a space base? The situtation at the moment is that the Space Station Task Group, headed by ex-British engineer John Hodge, is just about to define the requirements for such a base, although one of the reasons for Dr. Mark's European tour was to talk with ESA about a collaborative project. Spacelab is providing a good baseline for future cooperation and it could be that the station will not be American but an international venture.

Either way, Dr. Mark expects that it will probably take 2 to 3 years for full political approval to be given (NASA worked for some 4 years on the Shuttle before getting the final go-ahead in 1972), leading to orbiting hardware by the early 1990's.

When a station does roll off the design boards, some sort of rescue capability will be required—after all, the chances of a serious accident will increase as long-duration, large-crew missions get underway. One interesting rescue possibility was mentioned: the European "Hermes" mini-shuttle suggested by the French for launch atop Ariane. Not only that, but its flight test programme could kick off with it being carried into space *inside* the present US vehicle!

The problems of failures have to be taken into consideration in planning for both the present Shuttle system and any follow-on programme. Dr. Mark noted that today's astronauts spend 85% of their simulator time training for aborts, with only 15% devoted to the actual flight itself.

This raises the spectre of a serious setback with the present fleet of reusable craft. NASA admit they have need for only four Orbiters but—and this would seem to be a big "but"—the loss of only one would cause severe launch scheduling problems. For that reason alone, as Dr. Mark says, there would seem to be a good case for the much-touted fifth Orbiter. He mentioned that money has been provided for keeping the option open but the question of overall funding—if the green light is given—has yet to be resolved. It seems that the present proposals for private companies to finance a fifth craft in return for the right to act as agents for the entire fleet would encounter rough waters in Congress since some initial Federal funding would be required.

We *still* do not know if the Shuttle family of *Columbia, Challenger, Discovery* and *Atlantis* will be joined by a fifth member.

SUITED FOR SPACE

As Space Shuttle flights become routine, space walks, or extravehicular activity (EVA), will also become more common. Astronauts will be able to inspect the Orbiter and its payloads, perform external photography, and accomplish payload servicing such as film transfer. The space suit/backpack system is known as the extravehicular mobility unit, or EMU.

The Shuttle EMU is more advanced than the earlier Apollo versions—for one thing, it takes only five minutes to put on. There are no time-consuming zippers and all connections are just snapped together. The suit is also more flexible so it is easier to bend the joints. Rather than being custom designed for each astronaut as before, the EMU comes in assorted sizes (there are 15 different glove sizes, but only one helmet fitting).

To don the suits the astronaut first puts on a liquid cooling garment—a single piece jump suit with thin tubes for water cooling. Then, the astronaut slips into the lower torso (with integrated boots). He or she then reaches up into the hard upper torso mounted on a rack in the airlock. Next, the torso halves are snapped together with the waist ring. Finally, the gloves and helmet are attached. The helmet carries lights on each side which can be removed during EVA. The backpack, or Portable Life Support System, is already attached to the suit.

In preparation for the EVA, the astronauts rest in their suits while strapped to the walls of the airlock for 3½ hours. The airlock is a small chamber in the mid-deck of the Shuttle with one hatch to the inside and one opening to the cargo bay. During this time the astronauts breath pure oxygen rather than air of the Orbiter cabin to allow nitrogen in their blood to gradually come out of solution. This prevents the "bends" when the airlock is depressurized from the normal atmospheric pressure of the Orbiter to the suit operating pressure of 4.3 psi.

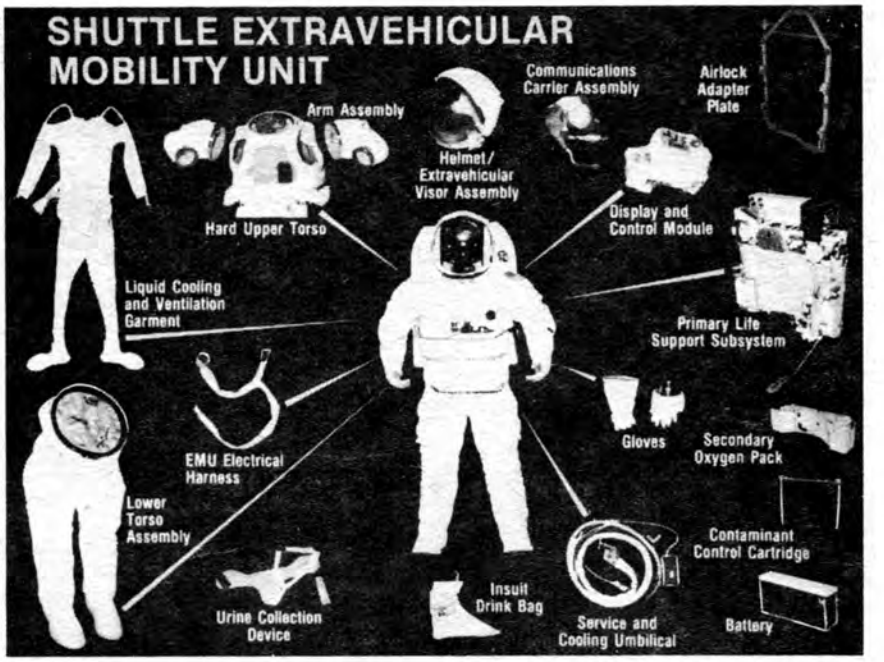
Finally, when the astronauts are accustomed to the pure oxygen of the space suits, all the air in the airlock is gradually released. The outer hatch is then opened.

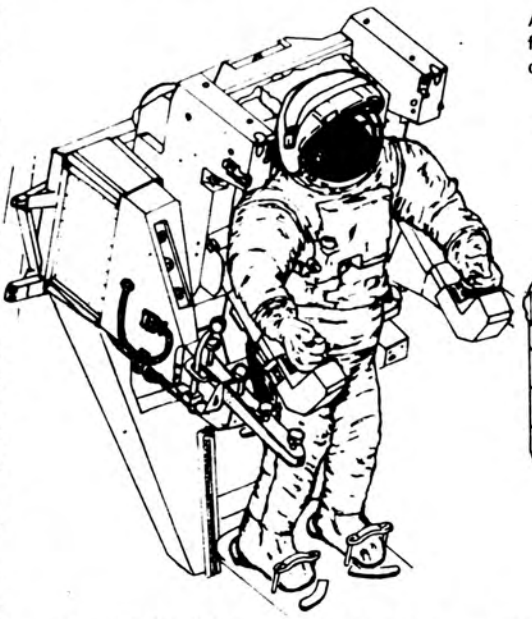
You may wonder why they go to so much trouble to use pure oxygen and have the suits at such a low pressure. Simply, at low pressures the suits are more flexible, although the pressure cannot be too low or there would not be enough to breath properly. Even at the operating pressue there is not enough oxygen in a normal air mixture to breath, hence pure oxygen has to be used. From experience, I can say that working under these conditions is perfectly comfortable and, aside from weightlessness, does not feel too different.

The backpack contains primary and backup oxygen supplies, a cooling system and a circulation system. Seven hours of expendables (water, power, etc.) are available. The backpack also carries the UHF radio powered by a silver zinc electrolyte battery. Both the battery and the oxygen supply can be recharged during flight.

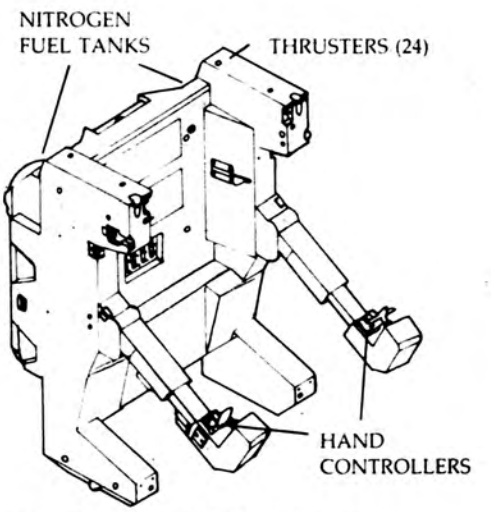
A display and control module is mounted on the suit's chest to monitor the oxygen pressure consumption rate, water temperature and pressure in the liquid cooling garment, and other vital functions. It uses a microprocessor which contains a program to display system check results on an LED display. The module also has a "push to talk" switch, a communications mode select switch, volume controls and a pressure gauge.

John Bird





An astronaut can don the EVA backpack from its mounting on the side of the cargo bay.



STS-13 TRAINING

Astronauts for the 13th Space Shuttle mission have been practising special repair procedures on a mock-up of the SMM satellite in the huge water tank at the Marshall Flight Center in Huntsville. They intend to capture the ailing satellite in orbit next April, repair it and release it to continue astronomical observations.

Launched on 14 February 1980, the Solar Maximum Mission satellite operated successfully for 10 months making important observations of solar flares. But since early 1981 it has been slowly spinning in orbit (one revolution every six minutes) after fuses blew on three of the four attitude control momentum wheels.

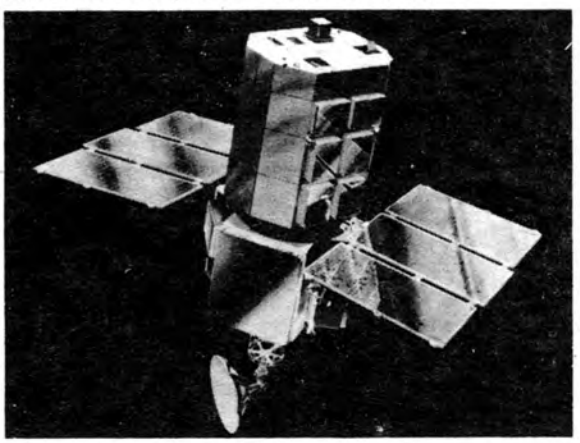
During the repair mission, Mission Specialists George Nelson and James van Hoften will replace the 230 kg attitude control unit and the main electronics box on the coronagraph/polarimeter instrument. Time permitting, other minor repairs will be made.

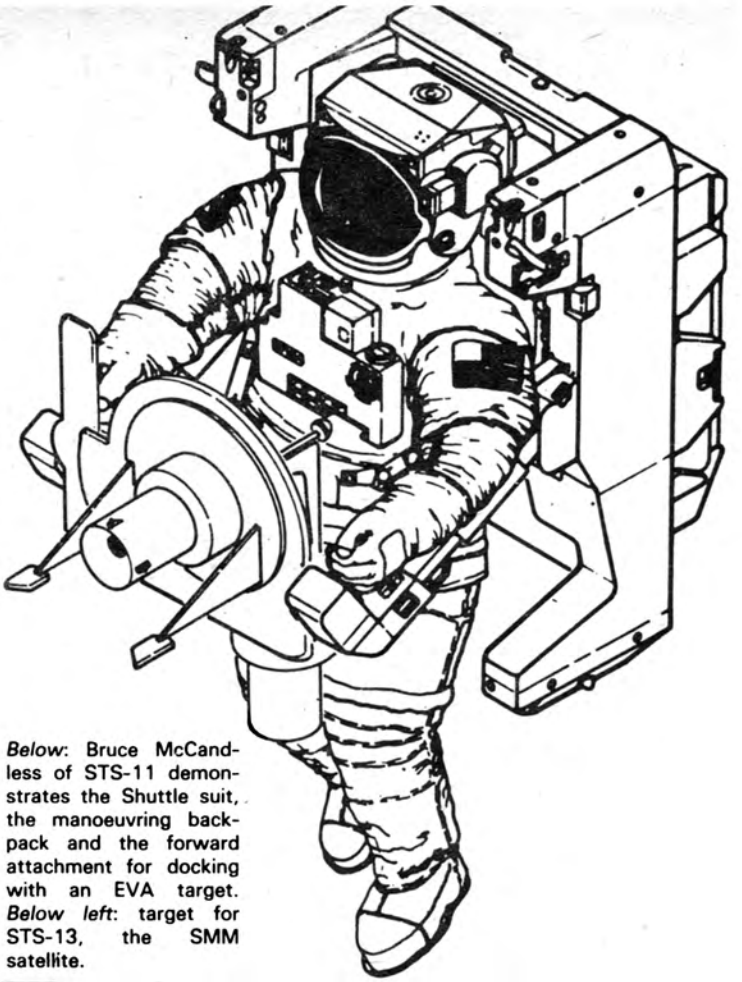
Last May, Nelson and STS-13 pilot Francis Scobee ran through the plan underwater watched by the Marshall Center's Dr. Ernie Hildner, a co-investigator on the spacecraft's failed coronograph/polarimeter. "I was very impressed at how feasible the simulation made it seem," he said. "The simulation made me more optimistic about the success of the endeavour."

Despite the problem in the guidance system, three of the seven instruments on board have continued to make some measurements. During the same simulations, astronaut Bruce McCandless practised using an underwater version of a Manned Maneuvering Unit (he will make the first space test of it on STS-11 in January).

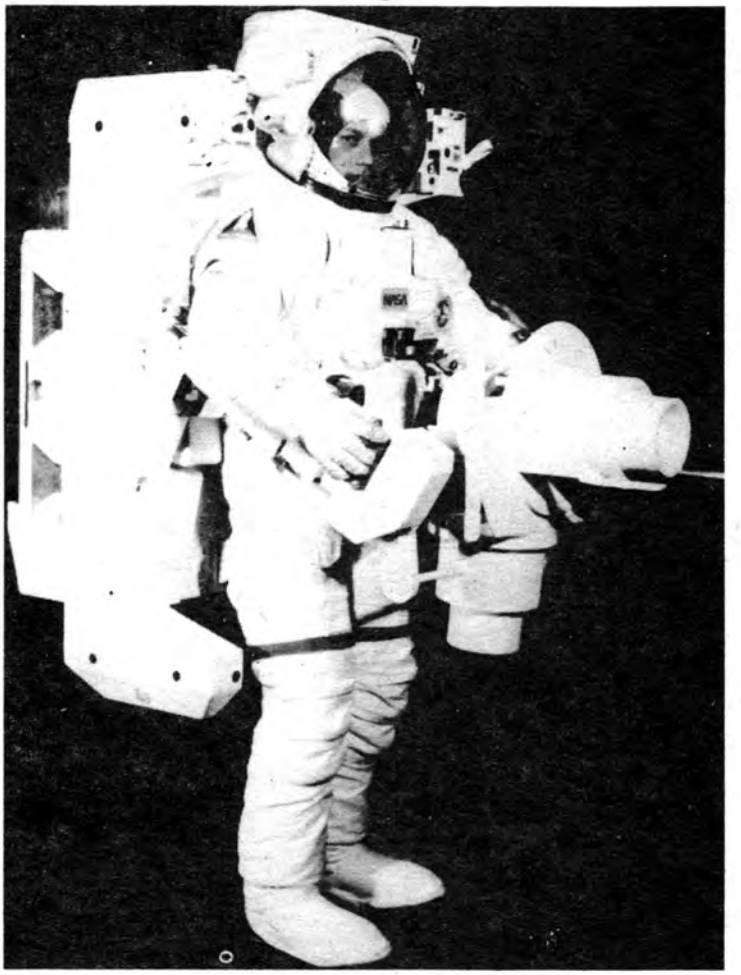
During STS-13, Nelson will strap on one of these units and travel 100 m from the shuttle to the turning satellite. He will dock and stabilise the satellite. *Challenger* will then move in, capture SMM with the Remote Manipulator Arm, and place it in the cargo bay for the repair work.

After the job is finished, SMM will be released and stabilised in a 530 km orbit. The hope is that it will once again be able to lock onto the Sun, providing a stable platform to allow the instruments to take precise measurements.





Below: Bruce McCandless of STS-11 demonstrates the Shuttle suit, the manoeuvring backpack and the forward attachment for docking with an EVA target. *Below left*: target for STS-13, the SMM satellite.



MEETING THE CHALLENGE

The success of the STS-7 mission in June and the smooth progress towards the flight of STS-8 seem to have put the Shuttle programme back on target. Donald F. Robertson takes a look back at the troubles that plagued *Challenger* before its maiden flight last April.

Clouds of steam burst from beneath Shuttle Orbiter *Challenger*, then thunder shattered the Florida silence of 18 December 1982. Yet the spacecraft did not rise. In fact, this engine test, only the second flight Readiness Firing of the Shuttle programme and required before any new Orbiter can fly, revealed a problem which ensured that, two months after *Challenger's* original 27 January launch date, STS-6 still had not left the pad.

What could possibly cause a two month delay in an operational programme which previously had been almost unbelievably successful?

Shortly after the test, abnormal concentrations of hydrogen gas were noticed inside the rear of the Orbiter, and the finger of blame pointed at some *external* source. Two potential sources were identified: unburnt hydrogen released during engine start-up, or gas from a leak later discovered in an engine's cooling jacket. Neither possibility was considered likely to endanger an actual launch since outside gas would be carried away by air flowing past the rising Shuttle.

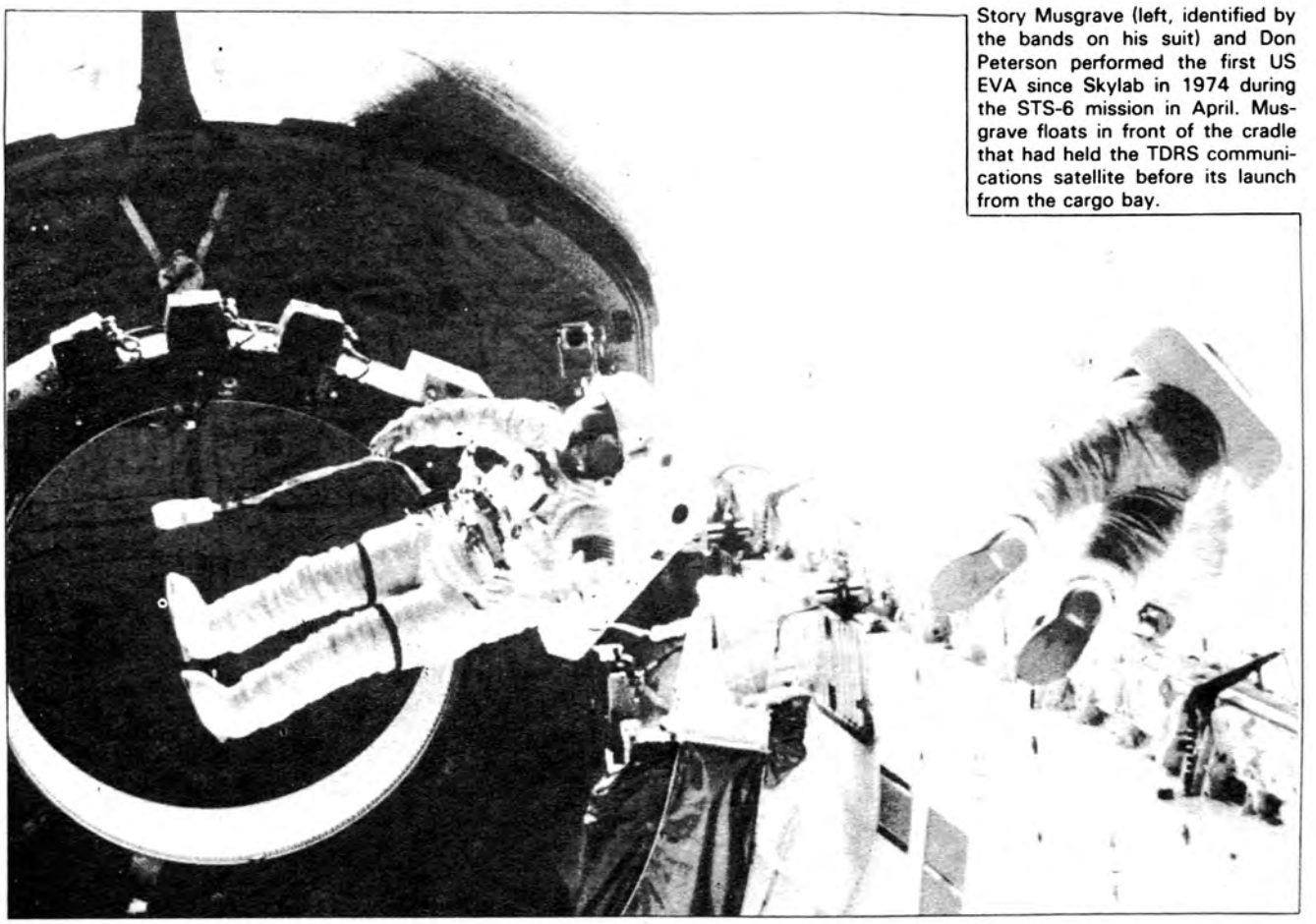
However, it could not be conclusively proved that the gas did not come from inside. Even if it did, it was not considered overly dangerous since, once the Orbiter has left atmospheric oxygen behind only 100 seconds after launch, both an oxygen leak and an ignition source would be needed to cause a fire. Still, NASA determined that the potential for disaster, however slim, was just great enough to warrant the expense and delay of a second Flight Readiness Firing.

Five weeks and $1.5 million later, *Challenger's* engines once again flared to life – and once again hydrogen leaked. The source was definitely internal. A mass-spectrometer sensing low pressure hydrogen flowing through *Challenger's* centre engine allowed a technician to get close enough to feel the leak on his arm.

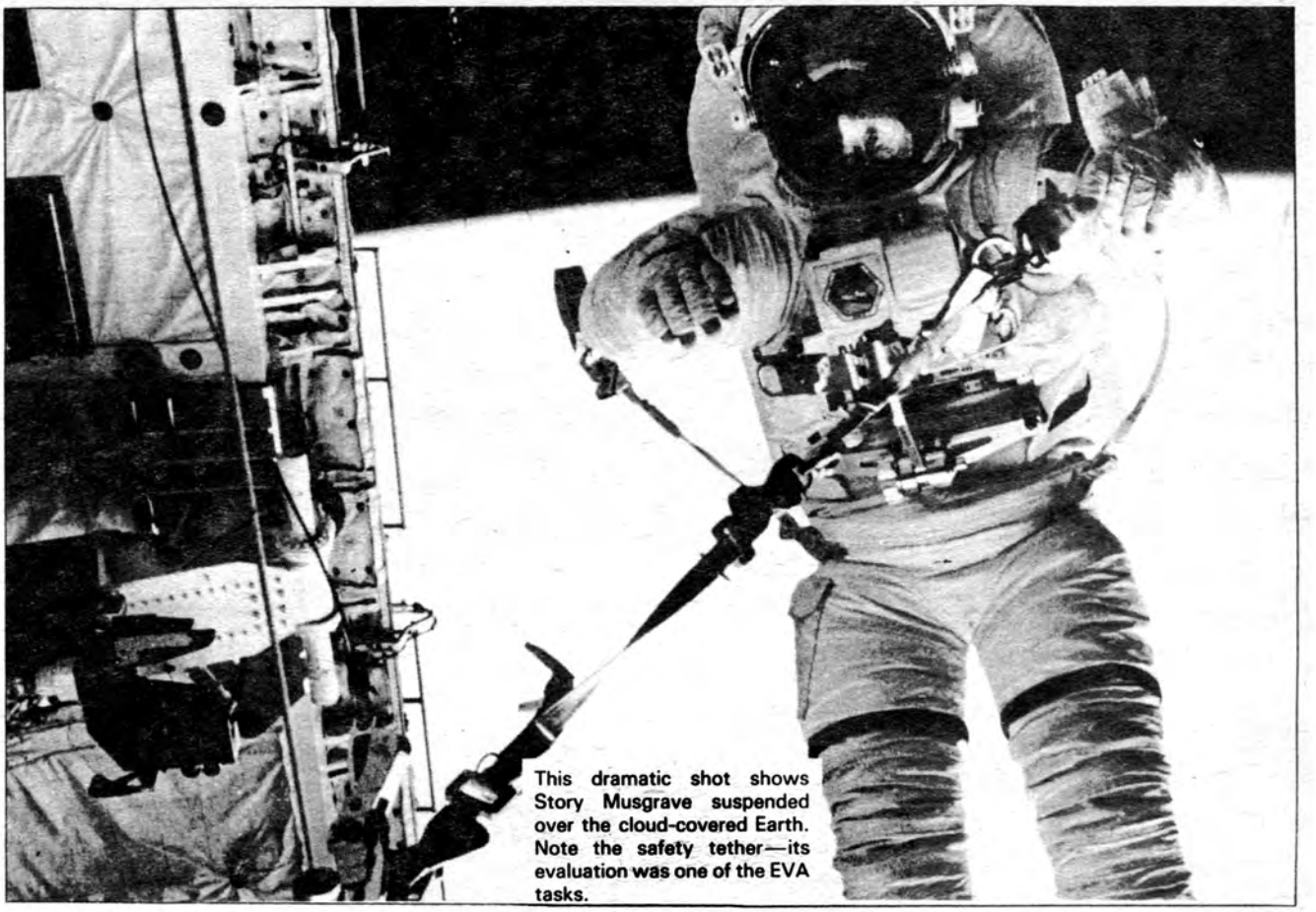
What can delay a shuttle flight two months? Answer: a 2 cm crack in a hydrogen coolant return line.

NASA briefly considered installing a Spacelab pallet with a system to remove the gas, but decided to replace the entire engine. Unfortunately, the spare engine then leaked oxygen from its oxidizer heat exchanger. As NASA was preparing to replace this engine with a new one previously intended for *Columbia*, yet another leak was discovered in one of the engines still on *Challenger!*

Internal inspection revealed cracks in the inside of a hydrogen line leading to a spark igniter. Apparently, heating caused by the addition of a sleeve intended to



Story Musgrave (left, identified by the bands on his suit) and Don Peterson performed the first US EVA since Skylab in 1974 during the STS-6 mission in April. Musgrave floats in front of the cradle that had held the TDRS communications satellite before its launch from the cargo bay.



This dramatic shot shows Story Musgrave suspended over the cloud-covered Earth. Note the safety tether—its evaluation was one of the EVA tasks.

prevent chafing when engines are operated at the 109 per cent power level cracked the line. The problem was subsequently found on a number of other engines, many of which had operated successfully in the past. It is possible that *Columbia* flew with undetected leaks. However, all of *Challenger's* engines now had to be replaced.

No new engine problems were discovered and, holding its collective breath, NASA planned for a 29 March launch. What else could possible go wrong?

A storm struck Kennedy Space Center on 25 February and continued into the 27th. Heavy rain and high winds pushed at the rotating service structure, breaking the seals which attach it to *Challenger's* payload bay with a supposedly airtight connection. This allowed the wind to enter, bringing contamination from outside and stirring up debris within the payload changeout room in the service structure. The result was contamination of the main payload, the Tracking and Data Relay Satellite.

No sooner had engineers completed vacuuming both the satellite and the interior of the payload bay and reinstalling the spacecraft when another storm, on 24 March, recontaminated the bay. The contamination was not so bad this time and the satellite was left alone. After the launch, modifications to both the pad structure and launch procedures were made to see that the same problem never again causes delays.

But even with the launch of STS-6 on 4 April, the problems were not over. In a truely dramatic sequence of events, the second stage of the Inertial Upper Stage, which was to drive the Tracking and Data Relay Satellite into a geostationary orbit, failed to work properly. Minutes after the second stage fired, data indicated the stage was out of control. US Air Force ground-based telescopes later showed a plume 180 degrees away from the rocket plume, suggesting the possibility of a fault in the engine's casing.

The satellite, meanwhile, was finally separated from the derelict booster in a 35,318 by 21,786 km orbit. After the successful removal of the satellite's 30 revolution per minute rotation, the belief emerged that the functional (although damaged) satellite could be raised to its proper orbit to serve out its full ten year life.

In sharp contrast, STS-6's other main feature, the first Shuttle space walk, was spectacularly successful. And the landing was worth even half a day in something that can only be described as a sand storm, although the weather people did not seem to think of it as that. However, your intrepid correspondent can provide the phenomenal quantity of desert sand washed from his hair and clothing in support of his case!

Such a happy ending was all very well, but NASA's customers are getting increasingly anxious. Most importantly, two Tracking and Data Relay Satellites are required to obtain maximum scientific results from Spacelab-1, currently scheduled to fly on STS-9 sometime between 30 September and 15 October. Spacelab's payload requires a launch within this period, or a wait until a new window opens next February.

THE ASTRONAUTS OF STS-8

Richard Harrison Truly

Truly was pilot of STS-2 (see *Spaceflight*, March 1982, p. 105) and, following the flight, he continued with Shuttle support duties between November 1981 and April 1982. He received his assignment for commanding STS-8 in April 1982.

Daniel Charles Brandenstein

Daniel Brandenstein was born on 17 January 1943 in Watertown, Wisconsin. He earned a B.S. in mathematics and physics from the University of Wisconsin in 1965, entering the US Navy that year and receiving flight training until May 1967. His naval career included two combat tours in Southeast Asia and assignments testing electronic warfare systems.

Brandenstein was selected for NASA in 1978 and, following astronaut training, was assigned to Shuttle support. He was named as pilot for STS-8 in April 1982.

Guion Stewart Bluford Jr.

Guion Bluford was born on 22 November 1942 in Philadelphia, Pennsylvania. He was awarded a B.S. in aerospace engineering from the state university in 1964; an M.S. and a Ph.D. in aerospace engineering from the Air Force Institute of Technology in 1974 and 1977 respectively. He entered the Air Force in 1964 and became a pilot the following year, flying combat missions in Vietnam and later becoming a pilot instructor.

Bluford was selected for NASA in 1978 and was assigned to the Shuttle programme, working on the Remote Manipulator System, Spacelab experiments and avionics.

Dale Allen Gardner

Dale Gardner was named as the second mission specialist for STS-8. Born on 8 November 1948 in Fairmount, Minnesota, he gained a B.S. in engineering physics from the University of Illinois. He entered the USN in 1970, receiving flight and technical training.

Selected for NASA in January 1978, he completed the astronaut training programme and was assigned to Shuttle support duties. He was named as a mission specialist for STS-8 in April 1982.

William Edgar Thornton

Bill Thornton, making his first flight after a 16 year wait, is one of NASA's oldest serving astronauts (54). As a medical doctor, he specialises in aerospace medicine, and was added to the STS-8 crew to study the problem of space sickness.

D. J. SHAYLER

SHUTTLE LAUNCH SCHEDULE

As the rate of Shuttle launches increase, the number of astronauts and payloads going into space will rise dramatically. *Spaceflight* will publish occasional lists of the missions and their crews, updating them when necessary. Here is the second:

FLIGHT/ORBITER/ LAUNCH/ DURATION	CREW	PAYLOAD
STS-8 *Challenger* 15 Aug/4d	Truly, CDR, 1 Brandenstein, P Bluford, MS Gardner, D., MS Thornton, MS	Insat 1B RMS test unit
STS-9 *Columbia* 30 Sep/10d	Young, CDR, 5 Shaw, P Parker, MS Garriott, MS, 1 Lichtenberg, PS Merbold, PS (ESA)	Spacelab 1
STS-10 *Challenger* 3 Nov/?d	Mattingly, CDR, 2 Shriver, P Buchli, MS Onizuka, MS ? AFSE	LATE NEWS: mission now cancelled, IUS problems. Crew to be reassigned?
STS-11 *Challenger* 29 Jan '84/7d	Brand, CDR, 2 Gibson, R.L., P McCandless, MS Stewart, MS McNair, MS	Palapa B-2 Westar MMU test
STS-12 *Discovery* 18 Mar '84/5d	Hartsfield, CDR, 1 Coats, P Resnik, MS Hawley, MS Mullane, MS Walker, PS	TDRSS-B MEA
STS-13 *Challenger* 17 Apr '84/5d	Crippen, CDR, 2 Scobee, P Nelson, MS Hart, MS Van Hoften, MS	LDEF SMM repair
STS-18 ? 23 Sep '84/7d	Overmyer, CDR, 1 Gregory, P Lind, MS Thagard, MS, 1 Thornton, MS, 1 ? PS ? PS	Spacelab 3

CDR: Commander; P: Pilot; MS: Mission Specialist; PS: Payload Specialist; AFSE: Air Force Space Engineer. Number after crew position indicates number of previous missions.

TDRSS is the large NASA communications satellite; Insat and Palapa are Indian and Indonesian communications satellites, respectively; LDEF is NASA's Long Duration Exposure Facility which will be released and then recovered in March 1985; SMM is the repair of the ailing Solar Maximum Mission satellite; Spacelab is the NASA/ESA manned laboratory. Westar is a communications satellite.

Resnik will be the second US woman astronaut; Crippen will be the first to fly the Shuttle three times. STS-9 carries the first 6-person crew. Charles Walker, STS-12, is a McDonnell Douglas engineer who will operate the electrophoresis unit.

THE ASTRONAUTS OF STS-9

The four Spacelab 1 scientists, from left: Owen Garriott, Ulf Merbold, Bob Parker and Byron Lichtenberg.

John Watts Young

The Commander of the first Spacelab mission will be John Young, the Commander of STS-1. Since STS-1 (see *Space Education* July 1981, p.30) he has continued in his role as Chief of the Astronaut Office, and supporting other Shuttle flights.

Brester Hopkinson Shaw Jr.

Brester Shaw was born on 16 May 1945 in Cass City, Michigan. He earned a B.S. degree in engineering mechanics from the University of Wisconsin in 1968 and an M.S. in the same subject in 1969. Entering the USAF in 1969, he underwent pilot training and received his wings in 1970. He attended the USAF Test Pilot School at Edwards AFB between 1975 and 1978 as a test pilot and instructor.

Shaw was selected for NASA in January 1978 and was assigned to Shuttle support duties. He was backup entry CapCom for STS-3 and prime entry CapCom for STS-4.

Owen Kay Garriott

Born on 22 November 1930 in Enid, Oklahoma, Garriott earned a B.S. in electrical engineering from the state university in 1952, and then entered the USN, serving as an electronics officer until 1956. In 1957 he received an M.S. in electrical engineering from Stanford University, followed by a Ph.D. in 1960. Between 1961 and 1965 he was associate professor of electrical engineering at Stanford.

Garriott was selected by NASA as a scientist astronaut in 1965. From 1967 to 1968 he served as the Chief of Apollo Applications (Skylab) Office and continued with Skylab duties until 1972. He was a CapCom for the Apollo 11 mission and was named as science pilot for the second manned Skylab mission, logging 13 hours and 42 minutes on EVA.

Between 1976 and 1978 Garriott was Director of Science and Applications and also Assistant Director for Space Science at the Johnson Space Center. He was selected as a Mission Specialist for STS-9 in August 1978.

Robert Allen Ridley Parker

Parker is the second Mission Specialist for STS-9. He was born on 14 December 1936 in New York and received a B.A. in astronomy and physics from Amherst in 1958, followed by a Ph.D., also in astronomy, from CIT in 1962. Between 1962 and 1967 he was associate professor of astronomy at the University of Wisconsin.

He was selected by NASA as a scientist astronaut in August 1967. Between 1967 and 1972 he was assigned to support duties in the Apollo programme and was named as a support crew member for Apollo 15, and served as a CapCom during the mission. In August 1971 he was named as a support crew member for Apollo 17, again serving as a CapCom.

Between August 1974 and August 1978 he was Chief of Scientist Astronauts at the Johnson Space Center, and was also assigned to Shuttle development. He was named as a Mission Specialist for STS-9 in August 1978.

Ulf Merbold

Dr. Merbold, a physicist, was born on 20 June 1941, in Greiz, West Germany. He received a diploma in physics in 1968 and a PhD from Stutggart University in 1976.

In 1977 he was selected as one of three ESA payload specialist candidates for the SL-1 mission, receiving the flight assignment in September 1982.

Byron K. Lichtenberg

Dr. Lichtenberg, a biomedical engineer and a former USA Air Force fighter pilot, is the second Payload Specialist on Spacelab 1. He was born on 19 February 1948 in Stroudsburg, Pennsylvania. He received a BS in Electrical Engineering in 1969; an MS in Mechanical Engineering in 1975 and his PhD in Biomedical Engineering in 1979.

From 1969–73 he was a pilot in the USAF and served a tour of duty in Vietnam.

Selected in June 1977 as one of the scientists to train for the SL-1 mission, he was named as one of two candidates for further training in May 1978, and as SL-1 Payload Specialist last September.

JOHN YOUNG–ONE MAN'S CONQUEST OF SPACE

By David J. Shayler

Part 5

Concluded from the June issue

The remarkable career of astronaut John Young is brought up to date in this final instalment, looking briefly at his work on the Apollo and Shuttle programmes.

Early Apollo Assignments

Following the completion of his Gemini assignments in the autumn of 1966 Young moved on to the Apollo programme. On 22 December 1966 he was named as the Senior Pilot for the backup crew of the second manned Apollo. With him were Tom Stafford (Commander) and Gene Cernan (Pilot).

From then until 27 January 1967 he trained for the mission but then the three Apollo 1 astronauts lost their lives in a fire on Pad 34 at the Cape. One of them was Gus Grissom, a friend of Young and his former Gemini 3 Commander. It was a personal loss for Young, who had spent the day with Stafford and Cernan at the Rockwell plant in Downey, California running tests similar to those the dead crew had undertaken at the Cape.

Following the fire all crews were stood down pending the results of the investigations. For many months all the astronauts helped in the inquiry and continued their basic training for new assignments. On 9 May 1967 the crew for the maiden flight (Apollo 7) of the redesigned Apollo spacecraft was announced, with Young as backup Command Module Pilot, again serving with Stafford and Cernan.

From May 1967 to October 1968 he trained for Apollo 7, and during the mission of 11–22 October 1968 he supported the flight from Houston and acted as an incidental CapCom.

Apollo 10

Shortly after the completion of his duties on Apollo 7, Young was named as CMP for the Apollo 10 mission, planned as a lunar orbiting dress rehearsal for the first landing. The Saturn 5 launch on 18 May 1969 took him into space for the third time.

Young flew solo in lunar orbit for eight hours while Stafford and Cernan guided the Lunar Module in a low pass over the lunar surface. After spending some 62 hours in lunar orbit the crew returned to Earth, leaving the way open for the historic Apollo 11 mission two months later.

Young now busied himself with a new assignment. On 5 August 1969 he was named as backup Commander for Apollo 13, with Swigert and Duke. Training lasted until April 1970 when Apollo 13 was launched on its ill-fated lunar mission. During the crisis period Young spent many hours in simulators working out procedures to bring the stranded crew home.

On 3 March 1971 he was officially named as the Commander for Apollo 16, with Duke and Mattingly. This time the training took over a year before the crew were poised atop their Saturn V awaiting the journey to the Moon.

Moon Walker No. 9

Flown 16 to 27 April 1972, Apollo 16 made the fifth manned lunar landing. For three days Young and Duke completed three periods of lunar surface EVA, during which time they deployed an ALSEP experiment package, drove the Lunar Roving Vehicle and collected samples. While on the surface they heard that NASA had received the Presidential go-ahead for the Shuttle.

The two lunarnauts rejoined their colleague in lunar orbit and headed home for a Pacific splashdown.

Expected to move onto the Shuttle programme, Young was reassigned on 23 May 1972 as the replacement backup Commander for Apollo 17, replacing David Scott who had been removed following the Apollo 15 stamp inquiry. The flight took place the following December.

The Shuttle

In January 1973 Young was assigned to the Shuttle branch of the Astronaut Office, from where he provided astronaut support for the design and development of the craft.

In January 1974 he became Acting Chief of the Astronaut Office (Alan Shepard was due to retire), and Chief a year later. This put him in the position of selecting crews for the Shuttle test flights in the late 1970's and early 1980's.

On 17 March 1978 it was announced that Young would fly the first orbital mission with Bob Crippen. For the next three years the two men trained for their two day test (described fully by John Pfannerstill in *Spaceflight*, 1982, p. 194, 295 and 460).

Following the completion of STS-1 Young resumed his duties as astronaut Chief but on 19 April 1982 he was named as the Commander for STS-9: the first in the Spacelab series. He will thus become the first man to make six trips into space. It is then expected that he will retire from the active flight list but remain with NASA as Chief of the Astronaut Office, training and selecting crews for future missions.

But with Young one never knows. Mission seven might be just around the corner!

SPACE COMMUNICATIONS

L-SAT/OLYMPUS

British Aerospace have announced plans for the world-wide marketing of a new class of multi-purpose communications satellites called Olympus, which will be the largest and most powerful commercial satellites yet built. It is expected to provide a substantial proportion of the world's direct broadcast and specialised business services between the late 1980's and the end of the century. Up to 150 of the craft might be produced.

The satellite is based on the technologies developed for ESA's L-Sat programme for which British Aerospace is prime contractor. The first L-Sat, now to be known as Olympus 1, will be launched in 1986 and will weigh 2300 kg. Future satellites will grow to 3500kg and generate over 7500 watts from solar arrays nearly 60 m across.

Olympus 1 will provide one direct broadast TV channel specifically for Italian use and another "steerable" channel for experimental use by members of the European Broadcasting Union. Olympus 1 will also carry 6 channels for mixed business communications using small Earth stations with antennae typically 3 m in diameter.

Higher power Olympus satellites will have the capability to broadcast five channels of direct broadcast television to large countries such as France or Spain.

This type of satellite is already a candidate for Canada's M-Sat and Radarsat programmes. The international consortium producing the satellites will also include Aeritalia, Selenia, Fokker and Spar Aerospace of Canada.

NEW SATELLITES

RCA is to design and build a two-satellite domestic communications system for the American Satellite Company.

The system will be based upon RCA's highly successful Satcom and Anik-B designs and will include the advanced technologies and improved performance now being incorporated in the next generation of communications satellites.

Each satellite will consist of 18 transponders at C-Band and six at Ku-Band. Communications will cover the 50 United States, Alaska, Hawaii and Puerto Rico. Both satellites are being designed for a 10-year life in orbit with the first launch scheduled in 1985 aboard the Shuttle.

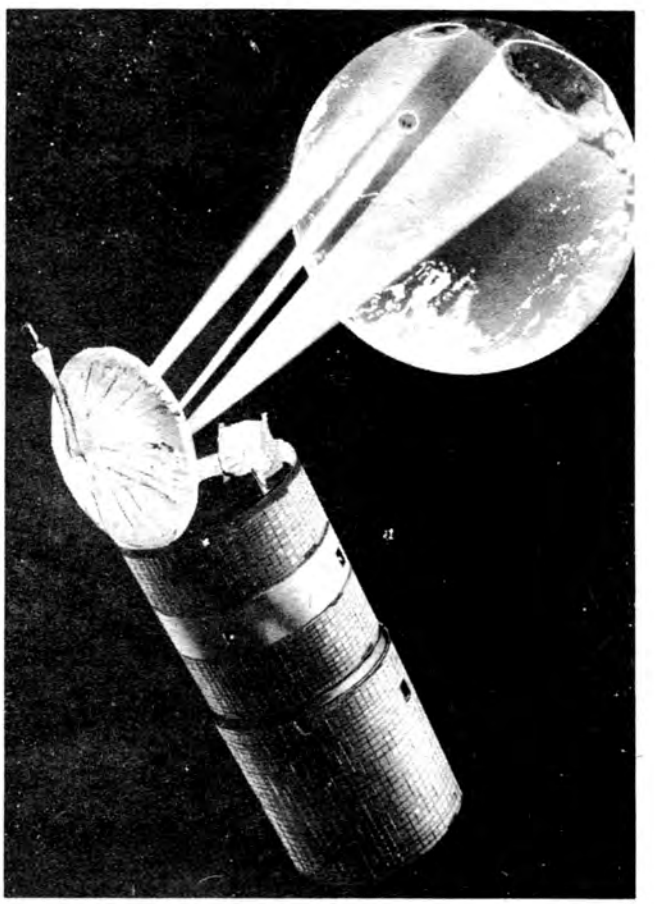
The craft will be the first commercial satellites with encoded command link security – to prevent false commands getting through.

GOODBYE TO ALL THAT

The problems of overcrowding in the much-used geostationary orbit 36,000 km high are becoming more apparent as increasing numbers of communication satellites are slotted into position there.

Apart from the difficulties arising from frequency interference between adjacent satellites there is always the physical danger of collision. It is now becoming the practice to move satellites out of that orbit when they come to the end of their useful lives.

Intelsat recently played their part by carefully conserving the attitude control propellant aboard their Intelsat IV F-2 satellite and using it in May to loft the craft 400 km above the main orbit. F-2 should now remain safely out of the way for several hundred thousand years.



The Galaxy 1 satellite, launched just before the seventh Shuttle mission (planning had to be careful to avoid a clash of launch requirements) is the first of a set of three owned by a Hughes subsidiary. Instead of leasing out the 24 transponders, cable TV programmers were able to buy them for the satellite's life.

F-2 was launched in January 1971 to a position over the Atlantic Ocean, acting in its later years as a spare to newer satellites. Eight of the type were launched between 1971 and 1975, seven successfully and with two still in service at the time of F-2's final manoeuvre.

(Crowding of the geostationary orbit was discussed in the December 1982 *Spaceflight*, pp.446–449).

MARITIME SATELLITE

Inmarsat (the International Maritime Satellite Organization) has signed a $64.5 million contract to lease the 40 voice-channel capacity of Marecs B2, a maritime communications satellite. It will be the ninth satellite in the Inmarsat system, which provides the capacity for telephone, telex, data and facsimile services for the shipping and offshore industries around the world.

The 38-member-country organization negotiated the contract for the satellite as a replacement for Marecs B, which was lost following a launch failure last September. A similar satellite, Marecs A, is already in operation over the Atlantic Ocean. The new satellite is expected to be launched in mid-1984 and positioned over the Pacific Ocean. The London-based Inmarsat organization is providing in-orbit spare satellites so that one satellite will be able to take over immediately should another fail.

Users of the Inmarsat system had reached 1757 by 1 May 1983. In addition to telephone and telex calls and distress alerts, the system can be used for transmitting data on ship engine performance, fuel consumption, position reporting, weather conditions, etc.

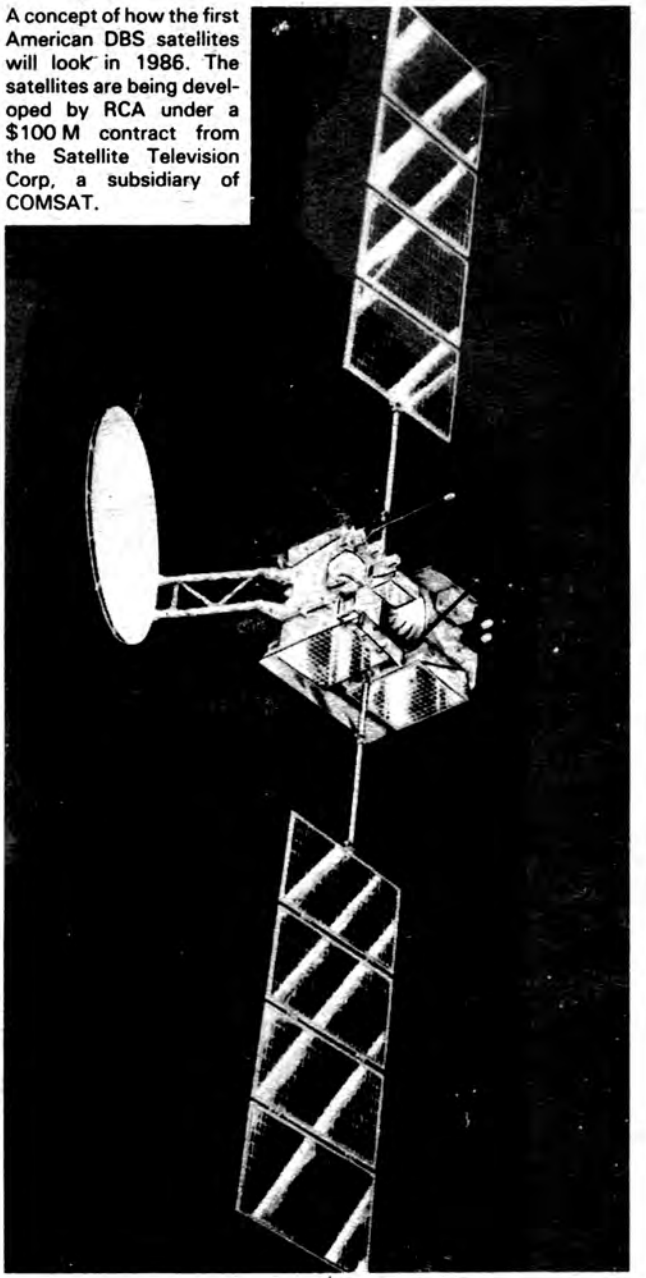
SATCOM IN ORBIT

The second advanced RCA Satcom US domestic communications satellite was launched on 11 April from Cape Canaveral by a Delta 3924 rocket. Designated as "RCA Satcom IR", the satellite replaces the first of the corporation's domestic satellites, Satcom I, which was launched on 12 December 1975.

Satcom I operates above 136 degrees west longitude, 36,000 km above the equator in geostationary orbit; the new satellite is positioned at 139 degrees west.

The satellites are the first operational, completely solid-state domestic communications satellites. The first advanced satellite, Satcom V, was launched on 27 October last year and put into operation early this year.

A shaped-beam antenna and 24 solid-state transponders (8.5 watts each) combine to improve traffic capacity. The new antennae provide stronger signal coverage to all 50 states. A large-aperature antenna reflector shapes the antenna beam, using multiple feed horns that have the size, location, power division and relative phasing to achieve the desired contour required. Solid-state transponders are a technological breakthrough resulting in greater reliability and increased traffic-handling capacity.



A concept of how the first American DBS satellites will look in 1986. The satellites are being developed by RCA under a $100 M contract from the Satellite Television Corp, a subsidiary of COMSAT.

NEW DBS SERVICES

Satellite Business Systems and Inter-American Satellite Television, Inc. announced on 6 May an agreement that will permit satellite-to-home TV services primarily for subscribers in rural or thinly populated areas in the United States writes Gerald Borrowman.

SBS will provide five satellite transponders and five transmit Earth station (uplinks) for services beginning later this year. The uplinks, standard SBS 5.5m Earth stations, will operate from a TV distribution centre in Los Angeles.

The five-channels will include at least one movie channel and a menue of news, entertainment, and cultural programming such as is commonly available to cable subscribers. Transmissions will be scrambled and will be available only to subscribers who purchase or lease dish antennae and decoding equipment.

SATELLITE DIGEST – 166

Robert D. Christy

Continued from the July–August issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

COSMOS 1442 1983–12A, 13850

Launched: 1245, 25 Feb 1983 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with a spherical re-entry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6 m, diameter (max) 2.4 m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered or re-entered after 45 days.
Orbit: 169×360 km, 89.81 min, 67.15 deg, manoeuvrable.

COSMOS 1443 1983–13A, 13868

Launched: 0930*, 2 Mar 1983 from Tyuratam by D-1.
Spacecraft data: Similar to Salyut 7 with length about 15 m, maximum diameter about 4 m and mass around 20 tonnes.
Mission: To enlarge the Salyut 7 laboratory and to carry consumables and experimental equipment to Salyut for use by following crews. Docked with Salyut on 10 Mar 1983.
Orbit: Initially 195×235 km, 88.70 min, 51.64 deg, then manoeuvred to meet Salyut.

COSMOS 1444 1983–14A, 13870

Launched: 1045, 2 Mar 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1442.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 358×416 km, 92.31 min, 72.84 deg, maintained by a low thrust motor.

MOLNIYA-3 (20) 1983–15A, 13875

Launched: 1530, 11 Mar 1983 from Plesetsk by A-2-e.
Spacecraft data: Cylindrical body housing instrumentation and the payload is surmounted by a conical motor section. Power is provided by a windmill of six solar panels. Length is about 4 m, diameter 1.6 m and mass around 2000 kg.
Mission: Transmits telephone, telegraph and TV signals through the "Orbita" system in the USSR and abroad.
Orbit: Initially 419×40796 km, 735.26 min, 62.83 deg. Orbit later adjusted by lowering apogee to produce a 718 min period, thus ensuring daily repeats of ground tracks.

EKRAN 10 1983–16A, 13878

Launched: 1410, 12 Mar 1983 from Tyuratam by D-1-E.
Spacecraft data: Cylinder with a pair of boom mounted solar panels and a transmitting array. Length 5 m, diameter 2 m and mass (in geostationary orbit) around 2000 kg.
Mission: To transmit programmes of Central Television to collective receiving stations in remote areas.
Orbit: Geostationary above 99 deg east longitude.

COSMOS 1445 1983–17A, 13883

Launched: 2235*, 15 Mar 1983 from Kapustin Yar by C-1.
Spacecraft data: Delta winged re-entry vehicle, length around 3 m and width about 2 m across the wings, mass around 1000 kg.
Mission: Re-entry and recovery test, recovered after less than two hours.
Orbit: 200×225 km, 88 min, 50.7 deg.

COSMOS 1446 1983–18A, 13886

Launched: 0850, 16 Mar 1983 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1442.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 222×241 km, 89.13 min, 69.94 deg, manoeuvrable.

MOLNIYA-1 (56) 1983–19A, 13890

Launched: 1810, 16 Mar 1983 from Plesetsk by A-2-e.
Spacecraft data: Similar to Molniya-3 (20) but mass around 1800 kg.
Mission: As Molniya-3 (20) but restricted to internal Soviet communications.
Orbit: Initially 453×40824 km, 736.53 min, 62.81 deg but later apogee lowered to produce 718 min period to ensure daily ground track repeats.

ASTRON 1983–20A, 13901

Launched: 1250, 23 Mar 1983 from Tyuratam by D-1-E.
Spacecraft data: Based on the Venera series of interplanetary craft. The basic vehicle is about 3 m long and 2.5 m diameter with a pair of solar panels. The experiments package consists of a set of X-ray spectrometers and a 5 m long ultraviolet telescope with a main mirror of 800 mm diameter. Overall mass about 3900 kg.
Mission: Astronomical research into faint objects using the X-ray and ultraviolet telescopes.
Orbit: 2000×200,000 km, 5880 min, 51.5 deg.

COSMOS 1447 1983–21A, 13916

Launched: 2050, 24 Mar 1983 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in a cylindrical solar array with length and diameter both about 2 m, mass aroung 700 kg.
Mission: Navigation satellite, combining its mission with the COSPAS search and rescue system.
Orbit: 960×1015 km, 104.88 min, 82.95 deg.

NOAA 8 1983–22A, 13923

Launched: 1600, 28 Mar 1983 from Vandenberg AFB by Atlas.
Spacecraft data: Box shaped, approx 4 m long and 2 m diameter, mass around 2000 kg.
Mission: Meteorological satellite, also carrying a SARSAT search and rescue system package similar in purpose to that on Cosmos 1447 (see above).
Orbit: 808×830 km, 101.30 min, 98.75 deg.

COSMOS 1448 1983–23A, 13949

Launched: 0110, 30 Mar 1983 from Plesetsk by C-1.
Spacecraft data: As Cosmos 1447.
Mission: Navigation satellite.
Orbit: 965×1005 km, 104.81 min, 82.96 deg.

COSMOS 1449 1983–24A, 13955

Launched: 1050, 31 Mar 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1442.
Mission: Military photo-reconnaissance, recovered after 15 days.
Orbit: 356×417 km, 92.30 min, 72.87 deg, maintained by a low thrust motor.

MOLNIYA-1 (57) 1983–25A, 13964

Launched: 0210, 2 Apr 1983 from Plesetsk by A-2-e.
Spacecraft data: As Molniya-1 (56).
Mission: As Molniya-1 (56).
Orbit: Initially 470×39005 km, 700.0 min, 62.91 deg, later apogee raised to produce

718 min period to ensure daily repeats of the ground track.

STS 6 1983-26A, 13968

Launched: 1830, 4 April 1983 from Kennedy Space Center, using Shuttle Orbiter *Challenger*.
Spacecraft data: Delta winged spacecraft, 37 m long, 24 m across, mass around 69 tonnes.
Mission: First flight of *Challenger* with crew of Weitz, Bobko, Peterson and Musgrave. Mission events included launching TDRS-A, EVA and a technical/scientific experiments programme. *Challenger* landed at Edwards AFB at 1853, 9 Apr 1983.
Orbit: 280X290 km, 90.0 min, 28.46 deg.

TDRS-A 1983-26B, 13969

Launched: 5 Apr 1983 from *Challenger* by IUS.
Spacecraft data: Irregular box + aerial and solar array, about 6 m long and 2 m diameter, mass around 1500 kg in geostationary orbit.
Mission: To provide improved spacecraft-to-ground communications for US-launched satellites.
Orbit: Lower than intended due to IUS second stage malfunction: 21857X35387 km, 1085.98 min, 2.37 deg, later manoeuvred to operating height by onboard thrusters, intended to be located above 41 deg west longitude.

COSMOS 1450 1983-27A, 13972

Launched: 1200 6 Apr 1983 from Plesetsk by C-1.
Spacecraft data: Not available.
Mission: Not known, but probably military.
Orbit: 470X515 km, 94.44 min, 65.85 deg.

RADUGA 12 1983-28A, 13975

Launched: 0445, 8 Apr 1983 from Tyuratam by D-1-E.
Spacecraft data: Similar to Ekran 10.
Mission: Round-the-clock radio, telegraphic and TV communications within the Soviet Union.
Orbit: Geostationary.

COSMOS 1451 1983-29A, 13975

Launched: 0840, 8 Apr 1983 from Plesetsk by A-2.
Spacecraft data: Similar to Cosmos 1442.
Mission: Photo-reconnaissance, recovered after 14 days.
Orbit: 227X323 km, 90.04 min, 82.35 deg.

RCA SATCOM 6 1983-30A, 13984

Launched: 2300, 11 Apr 1983 from Cape Canaveral by Delta.
Spacecraft data: Not available, mass around 1000 kg?
Mission: Communications satellite.
Orbit: Geostationary above 128 deg west longitude.

COSMOS 1452 1983-31A, 13991.

Launched: 1650, 12 Apr 1983 from Plesetsk by C-1.
Spacecraft data: Probably similar to Cosmos 1447.
Mission: Military communications using a store/dump technique.
Orbit: 785X810 km, 100.84 min, 74.04 deg.

OPS 2925 1983-32A, 14001

Launched: 1840, 15 Apr 1983 from Vandenberg AFB by Titan 3B-Agena D.
Spacecraft data: Cylinder about 8 m long and 1.5 m diameter, mass around 3 tonnes.
Mission: Military photo-reconnaissance.
Orbit: 135X298 km, 88.85 min, 96.52 deg, manoeuvrable.

ROHINI 3 1983-33A, 14002

Launched: 0554, 17 Apr 1983 from Sriharikota by SLV-3.
Spacecraft data: Not available.
Mission: Not known.
Orbit: 388X852 km, 97.02 min, 46.60 deg.

COSMOS 1453 1983-34A, 14006

Launched: 1200, 19 Apr 1983 from Plesetsk by C-1.
Spacecraft data: Not available.
Mission: Not known but military in nature.
Orbit: 470X517 km, 94.50 min, 74.03 deg.

SOYUZ-T8 1983-35A, 14014

Launched: 1311*, 20 Apr 1983 from Tyuratam by A-2.
Spacecraft data: Near spherical orbital compartment, conical re-entry module and cylindrical instrument unit with solar panels, length about 7.5 m, diameter 2.2 m and mass around 7000 kg.
Mission: To carry a crew of three: cosmonauts Titov, Strekalov and Serebrov to the Salyut 7/Cosmos 1443 complex. The mission failed before docking could be completed due to a malfunction in the rendezvous system. Soyuz-T8 was recovered after 2 days.
Orbit: Initially 180X228 km, 88.51 min, 51.62 deg, then manoeuvred to rendezvous with Salyut 7.

COSMOS 1454 1983-36A, 14017

Launched: 1440, 22 Apr 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1442.
Mission: Military photo-reconnaissance, recovered or re-entered after six weeks.
Orbit: 170X343 km, 89.64 min, 67.14 deg, manoeuvrable.

COSMOS 1455 1983-37A, 14032

Launched: 1430, 23 Apr 1983 from Plesetsk by F vehicle.
Spacecraft data: Not available.
Mission: Possibly electronic reconnaissance.
Orbit: 635X665 km, 97.76 min, 82.51 deg.

COSMOS 1456 1983-38A, 14034

Launched: 1940, 25 Apr 1983 from Plesetsk by A-2-e.
Spacecraft data: Similar to the Molniya satellites.
Mission: Part of the USSR's missile early warning system.
Orbit: Initially 620X39387 km, 710.71 min, 62.94 deg, later manoeuvred to 718 min orbit by lowering apogee to ensure daily repeats of the ground track.

COSMOS 1457 1983-39A, 14039

Launched: 1010, 26 Apr 1983 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1442.
Mission: Military photo-reconnaissance.
Orbit: 171X350 km, 89.71 min, 70.40 deg, manoeuvrable.

COSMOS 1458 1983-40A, 14044.

Launched: 0830, 28 Apr 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1442.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package. Recovered after 13 days.
Orbit: 212X245 km, 89.10 min, 82.32 deg.

GOES 6 1983-41A, 14050

Launched: 2220, 28 Apr 1983 from Cape Canaveral.
Spacecraft data: Spin stabilised drum, approx 3 m long, 2 m diameter, mass around 800 kg, including about 400 kg of fuel.
Mission: Return of meteorological data from geostationary orbit.
Orbit: Geostationary.

COSMOS 1459 1983-42A, 14057

Launched: 0300, 6 May 1983 from Plesetsk by C-1.
Spacecraft data: As Cosmos 1447.
Mission: Navigation satellite.
Orbit: 946X1020 km, 104.77 min, 82.97 deg.

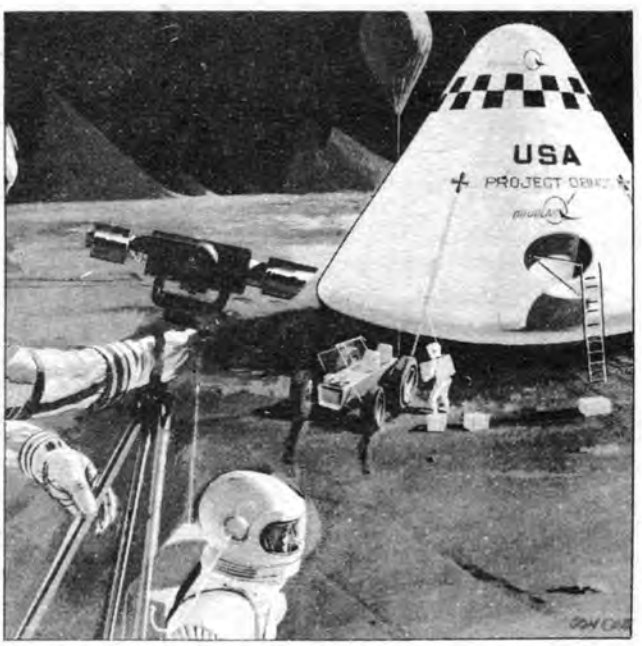
BOOK NOTICES

Mission to Mars
J.E. Oberg, Stackpole Books, 221pp, 1982, $14.95.

This book is not about the planet Mars itself but the problems of manned exploration and settlement of the planet, for the progression of space technology in the 1980's and 1990's will have the inevitable consequence of a manned interplanetary flight.

The author tackles these problems first by considering the transportation hardware needed, the selection of a site on Mars, scientific factors and how a human presence on Mars might be sustained. The author, however, goes far beyond presenting a purely technical appraisal. He is an enthusiast of the first order and not only plunges immediately into the arguments for the case for a Mars mission but also advocates steps which should be taken now to increase public awareness, particularly in the United States, of the possibilities and rewards of such a project.

It is these political and social issues that will determine the date when such a project is initiated. Whether this will be done as a conscious decision in its own right, or whether it will come in response to some spectacular Soviet initiative, has yet to be ascertained. There is no doubt at all, following the incredible success of the Viking landers, the time is right



for sophisticated probes to examine Mars in considerable detail. This would not only pave the way for a subsequent manned landing but would, at the same time, raise once more the "anti" argument – to the effect that manned missions are superfluous because unmanned missions are so much cheaper and produce just as much information.

The author is well aware of this and draws attention not only to the possibilities of exploiting mineral and other resources on the planet but also using the planet as a stepping stone to worlds beyond.

Venus
D.M. Hunten *(et al)*, University of Arizona Press, 1143pp, 1983, $49.95.

The exploration of Venus by spacecraft began in 1962 and has continued steadily ever since. By 1978, six probes had reached the surface, one had entered the upper atmosphere and three, an orbital and two flybys, had studied the environment. Two further Soviet probes were lauched to arrive there this October, and more are expected in 1985 on their way to meet Halley's Comet in 1986. The Americans plan the VRM radar mapping mission later this decade.

The 30 chapters in this compendium are divided almost equally between major surveys and the introductory and supplementary contributions, some of the latter being by Soviet authors and with other Soviet contributions integrated into the review chapters.

Like other books in this series, this one is built around a conference i.e. the International Conference on the Venus Environment held in 1981, but is rather more than simply a collection of conference papers for it actually amounts to a fully detailed volume which summarizes practically all that is known about the planet at the present time.

As might be expected, the atmosphere receives particular attention, detailing such matters as its thermal structure, composition, chemistry, electrical activity and dynamic state. Particularly interesting is a contribution on its origin and evolution. This seems to paint a picture of a Venus that began to evolve along a path similar to that of Earth but suffered a catastrophe, in the form of a runaway greenhouse effect early in its lifetime.

The review chapters and reports of results are well worth reading, as are the sections on radio and radar observation.

The Ultimate Fate of the Universe
J. N. Islam, Cambridge University Press, 153pp, 1983, $7.95.

The spate of books on the origin of the Universe has now been complemented by one which describes what will ultimately happen to it all.

To provide an understanding of the Universe in the far future, the author first describes its present state and structure on the grand scale and how its present properties arose. From that point he speculates about its future course and predicts the major changes likely to occur, e.g. the way in which normal stars finish their evolution by becoming white dwarfs, neutron stars or black holes. Black holes can coalesce to form larger black holes. From this the author deduces that supermassive black holes may already exist as the nuclei of galaxies and quasars.

All predictions on the evolution of the Universe strongly depend on the cosmological model adopted. This popular account is based largely on the standard big-bang model, though the steady state theory is also mentioned.

The volume concludes with the discussion of the stability of the proton since its very long, but finite, lifetime profoundly affects the evolution of the entire Universe.

Mathematical formulae are largely avoided to enable the book to be readily appreciated by readers with a modest background in physics and astronomy.

The New Solar System
Ed. J. Kelly Beatty *et al*, Cambridge University Press, 240 pp, 1983, £12.50.

This is the second edition of a volume which has well earned its popularity. It represents a compilation by a number of authors who have aimed to present short digests of new discoveries relating to the various bodies in the Solar System. The result is a "coffee-table" type of book but interesting on its own account not only because of its wide range of photographs and drawings but also because it is so well written.

In general, the material covers the period from the 1950's onwards with particular emphasis on photographs and other data returned by space probes. The text is easy to read but informative nonetheless. Few who obtain this book will be disappointed by it.

The Sun – Our Star
R. W. Noyes, Harvard University Press, 263pp, 1983, £16.

An astronomer from a distant planet, scanning the night skies, would scarcely pause to examine our Sun closely. Middle-aged, average in size and luminosity, the Sun is simply one among millions of similar bodies in the Milky Way.

To Earthly astronomers, however, the Sun reveals an astonishing complexity. Dark spots move across its face, the solar wind emerges from its mysterious coronal holes and great flares, more powerful than a million nuclear bombs, form part of its normal activity.

The author, in a well-illustrated volume, sets out to explain the structure and inner workings of the Sun, ranging from the nuclear reactions that turn four tons of matter into energy per second, to the intricate magnetic fields that produce solar prominences, flares and sunspots. He also traces its evolution, a story which began nearly five million years ago among a dark cloud of dust and vapour floating in the void among other young stars in the Milky Way.

After describing how the gravitational pull of these interstellar particles caused them to collapse inwards, compressing and heating until a vast nuclear furnace at the centre was ignited; the author continues by describing planetary formation and, completing the cycle, how the Sun will eventually expand to become a red giant, only to end its days as a tiny white dwarf.

Space Statistics Review 1983
Compiled by Aviation Information Services Ltd., 70pp, 1983, £93.

This review is primarily designed to provide data and statistics regarding the launching and positioning of satellites, particularly those in geosynchronous orbits. It is not intended to be a source of comprehensive data on other aspects though much information of a related character is also included, e.g. in regard to launch vehicles.

Of particular interest to space statisticians is the similarity of the early launch histories of the Ariane and Japanese 'N' vehicles to that of the Thor-Delta, Atlas Centaur and Titan vehicles.

The aim of the publication is to provide the updated background needed by space insurance underwriters. It highlights the fact there is no perfect method in expressing satellite launch failure statistics, if for no other reason than that the compilers found it necessary to use several different definitions of "failure".

NASA Astronaut Biographical Data Record Book
D.J. Shayler, Astro Info Service, pp. 130, 1983, £7.00 (soft cover).

This is a privately-produced booklet reproduced directly from a typed original, covering the careers of the NASA Group 5 astronauts selected in 1966.

Some of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

EXPANDING OUR TECHNICAL HORIZONS

The Society's pioneering spirit is eloquently expressed in the Interstellar Studies issues of *JBIS*. These explore ideas and concepts that will take Man to the Stars. With almost 40 issues so far it is recognised as the world leader in its field.

Special issues of *JBIS* deal with other topics – Space Communications, Space Technology, Orbital Dynamics, IRAS – all featuring the Society's technical interests. Future issues planned include "Halley's Comet" and "Advanced Space Concepts".

The Society welcomes offers of scientific and technical contributions on all aspects of space for inclusion in its meetings and publications. Members in industry, universities and government research establishments, both in the UK and abroad, are invited to bring this invitation to the attention of their colleagues. Specimen copies may be sent to interested parties.

Help the Society to expand its technical reputation worldwide.

38th ANNUAL GENERAL MEETING

NOTICE IS HEREBY GIVEN that the 38th ANNUAL GENERAL MEETING of the BRITISH INTERPLANETARY SOCIETY Limited will be held in the Lancaster Room, Caxton Hall, Caxton Street, London SW1 on Saturday, **24th September 1983** at 3 p.m. precisely

AGENDA

1. To receive the Report of the Council on the Society's Affairs for the year to 31st December 1982
2. To receive the Society's Balance Sheet and Accounts for the year ended 31st December 1982 and the Auditors' report thereon.
3. To appoint Auditors and determine the method of fixing their remuneration. The present auditors have expressed their interest in continuing in Office.
4. To elect four Members of the Council of the Society. In accordance with article 15 the following Members of the Council will retire at the meeting:

   A.T. Lawton — G.J.N. Smith
   R.C. Parkinson — C.R. Turner

If the number of nominations exceeds the number of vacancies, election will be by postal ballot in accordance with Article 44. The final date for the receipt of ballot papers will be 31st January 1984.

5. General Discussion.
6. Closing Remarks by President.

By Order of the Council
L. J. CARTER,
Executive Secretary.

A member who cannot be personally present at the meeting may appoint by proxy some other person, who must be a member of the Society, to attend and vote on his behalf, subject, however, to the proviso that a proxy cannot vote except on a poll.

BRITISH INTERPLANETARY SOCIETY LIMITED (BY GUARANTEE)

REPORT OF THE AUDITORS

We have audited the financial statements set out on pages 2 to 6* in accordance with approved Auditing Standards.

In our opinion the financial statements, which have been prepared under the historical cost convention, give a true and fair view of the state of affairs of the Society at 31st December, 1982 and of the result for the year ended on that date and comply with the Companies Acts 1948 to 1981, insofar as the provisions of those Acts apply to these financial statements.

The financial statements do not specify the manner in which the operations of the Society have been financed or in which its financial resources have been used during the year as required by Statement of Standard Accounting Practice No. 10.

FRASER KEEN
Chartered Accountants

4 London Wall Buildings
London EC2M 5NT

**Refers to original documents*

Balance Sheet as at 31st December, 1982

1981 £		Notes	£	£
102,211	*FIXED ASSETS*	2		85,749
28,077	Investments at Cost	3		38,712
130,288				124,461
	CURRENT ASSETS			
—	Stock of Publications		4,000	
726	V.A.T. Recoverable		970	
25,792	Bank: Current Account		12,280	
	Deposit/Giro – 1983			
52,716	Subscriptions	63,667		
	Less 1983 Subscriptions in			
52,716	advance	63,667	—	17,250
156,806				141,711
	LESS: CURRENT LIABILITIES			
110	Sundry Creditors		1,643	
3,198	London Borough, Lambeth		—	
16,574	Bank Overdraft		—	1,643
£136,924	*NET ASSETS*			£140,068
	Represented by:			
	ACCUMULATED FUND			
126,576	Balance at 1.1.1982			136,924
10,348	Excess of Income over Expenditure for year			3,144
£136,924				£140,068

Income and Expenditure Account for the year ended 31st December, 1982

1981 £		£	£
	INCOME		
75,101	Subscriptions from Members	75,633	
34,554	Sale of Publications	40,184	
11,038	Income from Investments	9,614	
1,041	Sundry Receipts	1,070	
121,734			126,501
	Less: EXPENSES		
	Office and Administration		
29,575	Salaries and National Insurance	31,110	
8,855	Rent, Rates, Light, Heat, Cleaning, Insurance and Repairs	10,735	
300	Audit and Accountancy	350	
4,281	Postage, Stationary and Telephone	3,902	
120	Sundry Expenses	417	
2,856	Depreciation: Buildings	2,856	
2,093	Fixtures, Fittings and Equipment	5,591	
	Members Services		
60,618	Publication of Magazines	65,313	
1,014	Meeting Expenses	1,138	
494	I.A.F. Contribution and Expenses	1,363	
1,180	Library Expenses	582	
111,386			123,357
£10,348	Excess of Income over Expenditure		£3,144

Notes to and forming part of the financial statements for the year ended 31st December, 1982

1. *ACCOUNTING POLICIES*
   (a) *Depreciation*
   Depreciation has been provided at rates which are considered appropriate in reducing the cost of the assets to their

residual value over their estimated useful life. The rates used are:

Freehold Buildings – 2% on a straight line basis
Fixtures, Fittings and Equipment – 10% on a straight line basis and for certain equipment
25% on a reducing balance basis

(b) *Stocks*
Stock consists of publication and sundry items valued at the lower of cost or net realisable value by the Executive Secretary.

2. *FIXED ASSETS*

	Freehold Land and Buildings £	*Fixtures, Fittings and Equipment* £	*Library* £	*Total* £
COST				
Balance at 1.1.1982	176,768	20,928	11,467	209,163
Additions during year	—	11,380	—	11,380
Items scrapped or written off	—	(10,000)	—	(10,000)
Balance at 31.12.1982	£176,768	£22,308	£11,467	£210,543
DEPRECIATION				
Depreciation at 1.1.1982	8,484	6,610	—	15,094
Charge for year	2,856	5,591	—	8,447
Items scrapped or written off	—	(10,000)	—	(10,000)
Balance at 31.12.1982	£11,340	£2,201	—	£13,541
Balance at 31.12.1982	165,428	20,107	11,467	197,002
Less: Contributions received to date	79,679	20,107	11,467	111,253
N.B.V. at 31.12.1982	£85,749	—	—	£85,749

3. *INVESTMENTS*

1981		*No. of Units*	*Cost*
£			£
4,088	Income Units	13,215	4,529
162	Financial Security	272	168
3,827	High Yield	10,456	4,015
8,077			8,712
20,000	Staff Pension Fund – Special Deposit Account		30,000
£28,077			£38,712

The market value of the quoted investments at 31.12.1982 was £13,442 (1981 – £11,096).

BENEVOLENT FUND

FOR THE YEAR ENDED 31st DECEMBER 1982

	1982 £	*1981* £
Appeal Account		
Balance at 1.1.1982	9,904	8,838
Interest and Dividends (Gross)	1,020	1,066
	£10,924	£9,904
Investments		
2,614 Save and Prosper High Yield Units	1,001	954
3,299 Save and Prosper Group Unit	1,130	962
Bank Deposit Account	8,709	7,988
Debtor: Tax on dividends	84	—
	£10,924	£9,904

The market value of the quoted investments at 31.12.82 was £3,280 (1981 – £2,649).

1982 CALENDAR OF EVENTS

GENERAL MEETINGS AND LECTURES

13 Jan	Discussion: "Manned Exploration of the Planets".
20 Jan	Lecture: "Stars, the Source of Life" by C. A. Whyte.
27 Jan	Lecture: "Recent Advances in our Knowledge of the Sun" by Dr. G. O. Gough.
10 Feb	Lecture: "The Return of Halley's Comet" by M. J. Hendrie.
24 Feb	Film Show: "Space Satellites".
11 Mar	Lecture: "The 1950's Popularization of Space Travel" by A. B. Perkins
24 Mar	Film Show: "The Making of an Astronaut (Pt. 3)".
31 Mar	Lecture: "Manned Spaceflight Comes of Age" by P. S. Clark.
7 Apr	Lecture: "The Stability of the Solar System" by Prof. A. E. Roy.
5 May	Lecture: "The Turbulent Sun" by Dr. G. Simnett.
22 Sep	Discussion: "Solar Sails".
6 Oct	Film Show: "Steps to the Moon (Pt. 1)".
27 Oct	Film Show: "Steps to the Moon (Pt. 2)".
17 Nov	Film Show: "Steps to the Moon (Pt. 3)".
8 Dec	Film Show: "Steps to the Moon (Pt. 4)".

TECHNICAL SYMPOSIA & CONFERENCES

20 Apr	Symposium: "Space Transportation Systems for the 1980s".
19 May	Symposium: "Space Communications".
5/6 June	Symposium: "The Soviet Space Programme".
27 Sep	33rd IAF Congress, Paris, France.
18 Oct	Conference: "The Space Transportation System".
12–14 Nov	Conference: "Space '82" in Brighton.

STUDY COURSES 1982

Theme: Remote Sensing

6 Jan	"Remote Sensing: Needs and Applications in Developing Countries" by Dr. E. C. Barrett.
17 Feb	"Remote Sensing by Landsat and Weather Satellites" by Dr. R. Harris.
10 Mar	Technical Film Show.

Theme: Update Your Astronomy

12 Oct	"Updating Quasars" by Dr. R. Carswell.
24 Nov	"The Early Universe" by Dr. J. D. Barrow.
1 Dec	"Observational Cosmology" by Dr. J. Wall.

BUSINESS MEETING

25 Sep	37th Annual Meeting.

OTHER EVENTS

13 Oct	"First Night" Social evening at HQ.

MEMBERSHIP OF THE COUNCIL

President:	A. T. Lawton	
Vice-Presidents:	Dr. A. R. Martin	
	M. R. Fry	
Other members:	G. W. Childs	G. J. N. Smith
	T. J. Grant	G. V. E. Thompson
	Prof. G. V. Groves	C. R. Turner
	Dr. R. C. Parkinson	G. M. Webb
	Dr. L. R. Shepherd	

SPACEFLIGHT

JBIS

Space Education

If you want the full story of Man's journeys into the cosmos then look no further! The British Interplanetary Society publishes three excellent magazines, with something to suit all tastes.

The profusely-illustrated *Spaceflight* carries wide-ranging news and views on what is going on today in the space-world—it is vital reading for everyone interested in space travel. It deals with current events and future plans in news items and major articles, many of them written by leading space experts. Personal accounts give an "I-was-there" feeling to it all. And a lively correspondence section gives everyone a chance to air their views.

Spaceflight is not just a magazine; it is part of a network bringing together everyone interested in space.

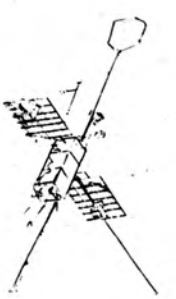
JBIS holds an exceptional place in the history of space exploration. First appearing in 1934, when interest in such matters was regarded almost as a heresy, it has since become a leading international publication, greatly respected for its emphasis on key topics. Many of today's developments were originated in its pages.

JBIS devotes issues to specific topics, such as Interstellar Studies, Space Technology, Space Communications and Astronautics History. Its Space Chronicle issues include general articles of a review nature.

Space Education is our latest venture. It's a twice-yearly magazine, established in 1981, devoted to the role of education in space exploration. It is a medium for the dissemination of information and the exchange of ideas on the teaching of space-related subjects and on their relation to the world of employment and industrial activities.

Membership of the Society entitles each member to receive either *Spaceflight* or *JBIS* free, with the other available at an extra cost of £20 ($34).

If you would like us to send a sample copy to a friend, please write to the Society at 27/29 South Lambeth Road, London SW8 1SZ.



Membership fees for 1984 are as follows:

	Sterling	US Dollars
Member (under 18)	£16	$26
Member (18–20)	£18	$30
Member (21+)	£21	$36
Fellow	£23	$40

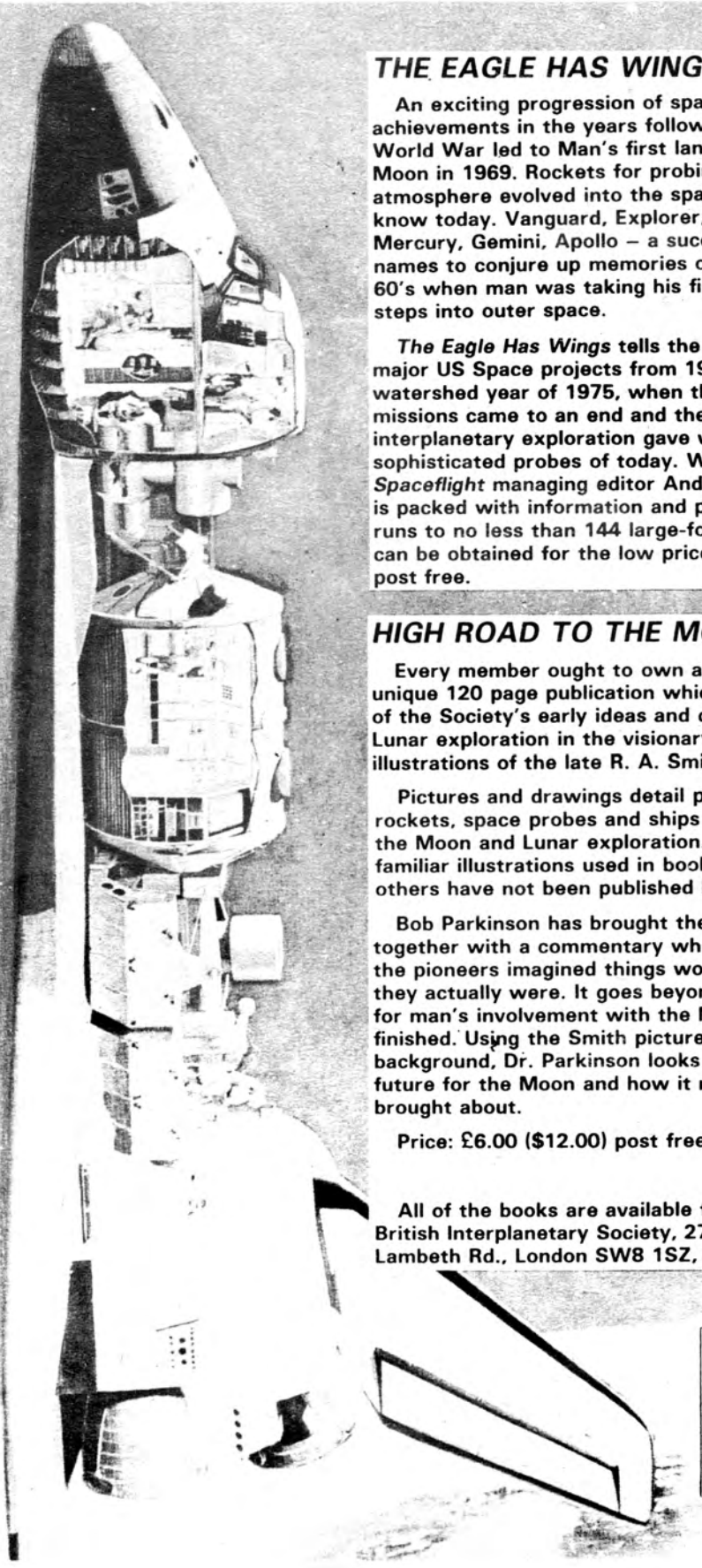
SOCIETY BOOKS

PROJECT DAEDALUS

The publication of the Project Daedalus Final Report marked the end of years of painstaking work by a group of BIS pioneers. The BIS received congratulations from around the world for its far-sighted project: designing a probe for man's first crossing of interstellar space.

The Final Report Report contains 24 papers spread over 192 large-format (A4) pages, summarising the four year study. The papers cover the overall spacecraft design, mission profile, computer systems, navigation, experiments and our knowledge of nearby stellar systems, some of them possibly with planets.

"Daedalus" is acknowledged as a milestone in the the development of advanced astronautics. Copies of the Report cost just £7.00 ($14.00) post free.



THE EAGLE HAS WINGS

An exciting progression of space achievements in the years following the Second World War led to Man's first landing on the Moon in 1969. Rockets for probing the upper atmosphere evolved into the space launchers we know today. Vanguard, Explorer, Atlas, Titan, Mercury, Gemini, Apollo – a succession of names to conjure up memories of the 50's and 60's when man was taking his first tentative steps into outer space.

The Eagle Has Wings tells the story of the major US Space projects from 1945 to the watershed year of 1975, when the Apollo missions came to an end and the first wave of interplanetary exploration gave way to the more sophisticated probes of today. Written by *Spaceflight* managing editor Andrew Wilson, it is packed with information and photographs. It runs to no less than 144 large-format pages and can be obtained for the low price of £7 ($14.00) post free.

HIGH ROAD TO THE MOON

Every member ought to own a copy of this unique 120 page publication which records many of the Society's early ideas and discussions on Lunar exploration in the visionary drawings and illustrations of the late R. A. Smith.

Pictures and drawings detail plans for orbital rockets, space probes and ships to take men to the Moon and Lunar exploration. Some are familiar illustrations used in books of the time: others have not been published before.

Bob Parkinson has brought these pictures together with a commentary which tells how the pioneers imagined things would be and how they actually were. It goes beyond the present, for man's involvement with the Moon is not yet finished. Using the Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.

Price: £6.00 ($12.00) post free.

All of the books are available from: The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ, England

FROM THE SECRETARY'S DESK

In the Beginning . . .

The Council, in their light and wisdom, has requested a regular light-hearted contribution (hard to do for someone whose Monday morning feeling generally persists until late Sunday evenings) to extend that feeling of personal contact with members which they value so highly and to encourage "a sense of belonging" by providing further background to many of the Society's activities.

The first thing to explain is where our cartoon logo above came from. It arrived by courtesy of TRW's *Sentinel*, and particularly the goodwill of its editor who freely allowed us to use it. The cartoon was first used in our June editorial but has now been purloined for this column, with the alternative of a satellite, in the shape of a hamburger, rejected.

Visit to RGO

Members who went on the visit to Royal Greenwich Observatory in April enjoyed themselves very much as will be apparent from the write-up in October's *Space Education*.

As the Executive Secretary was conspicuous by his absence, perhaps a few words of explanation are in order.

While everyone else was having a whale of a time, I was actually down to basics at the RGO Library, in readiness for the next Library Committee Meeting. The RGO Library has an annual budget of £20,000 and a stock of approximately 30,000 volumes. This includes an extremely valuable collection of early astronomical works, some very rare indeed. One of its Librarians in former days must have had a great sense of fun. He had had all the eccentric and dotty theories bound together as a volume entitled "Tracts – Paradoxical". Some of its contents caught my eye, quite by chance. One was from the *Journal of Science* in 1888 entitled "The Misapprehensions of Adams and Le Verrier" – presumably to the effect that there was no trans-Uranian planet while the second, dated 1891 was entitled "The Existence of *two* Trans-Neptunian Planets".

Society Publicity

Although the old adage "Yesterday's news is no news" undoubtedly applies to the press, it doesn't always relate to books. An example of this occurred recently. Quite by chance, I picked up a copy of *How it Works – The Rocket* (Ladybird Books) – perhaps in a subconscious attempt to update myself – and was astonished to see acknowledgements both to myself and to the Society on the opening page. Much furrowing of the forehead brought to light the realisation that this was an act of charity perfomed upwards of 20 years ago – still going strong and providing the Society with continuing publicity.

The subject of rockets appeared again in an extract from The Times of 27 October 1855 sent by Mitch Sharpe for my further edification. This was an item of correspondence headed "Monster Rockets" which read:

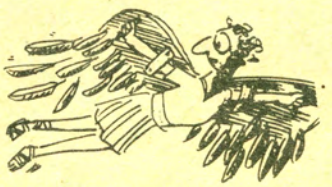
Your correspondent "Anticipator" has been anticipated. I have seen at the factory of Wade and Co., successors of Sir. W. Congreve, the moulds for a monster rocket. Twelve of the largest Congreve rockets placed round a barrel of gunpowder with a stick 25 feet long, form the monster rocket. It is placed in position by tackle. I was informed three such rockets had been made and tried, and that the effect was terrific. I believe that I am correct in stating that the cost averaged 150/- each, this cost, of course, including moulds, tackle, experiments, & c. The rockets were designed and the cost borne by some gentleman of fortune with a fancy for missiles.

As the letter was signed "C", I think Mitch wanted to check if I had written it.

Our Equipment Needs Renewing

Several members have asked for more information about our Equipment Appeal, particularly as they were interested in Word Processors. Our target of £30,000 was thought to be enough to buy a range of equipment to help with publishing, with word processors as the most expensive individual items.

All this stems from the fact that our IBM Composer is now on its last legs. It has given Trojan service in the past but is now reaching the end of its useful



lifetime. Up to now all 12 annual issues of *JBIS*, as well as the three books we have published so far, have been set by Ms. S.A. Jones, virtually alone and unaided, using this machine. Now obsolescence stares us in the face and a new initiative is required.

We soon found out that simply to replace the IBM with phototypesetting equipment would, on its own, cost well over £30,000 and so absorb everything raised by the Appeal, even assuming that we reached our target right away. Nothing would be left over for other things. By dint of further perseverance we found that we could get by on Decmate II Word Processors instead, which were considerably less expensive. These would allow us to feed coded typewritten text in at one end, with subsequent decoding into printed text by Unwins, our printers, at the other end.

Space '84

A note for your diary. Space '84 will be held at Brighton on 16–18 November 1984. The theme this time will be "Space – The Future of Mankind". Session headings, sufficiently stimulating and exciting to satisfy even the most fastidious, have provisionally been planned as follows: New Frontiers; Space Workshop; Foothold in Space; Discovering the Universe; The Future of Mankind; Ways and Means.

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

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NOTICES OF MEETINGS

38th Annual General Meeting

The 38th Annual General Meeting of the Society will be held in the Lancaster Room, Caxton Hall, Caxton Street, London, SW1 on Saturday **24 September 1983,** commencing 3.00 p.m.

Details of the Agenda appears in this issue of *Spaceflight*.

Symposium

A one-day meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London SW8 1SZ, on **5 October 1983,** 9.30 a.m. to 5.00 p.m.

Theme: **FUTURE PLANETARY MISSIONS**

The provisional programme is as follows:

A. 1. A Survey of European Space Agency Planetary Mission Planning
by G. P. Haskell

2. The Mariner Mark II Program
Speaker to be announced

B. Summaries of Scientific Objectives in the Study of:

1. Planetary Bodies
by Prof. K. Runcorn

2. Planetary Atmospheres
by Dr. G. Hunt

3. Small Bodies
by Dr. D. Hughes

C. 1. Launcher Capabilities and Missions Opportunities
by R. Buckland

2. Manned Planetary Missions?
by Dr. R. C. Parkinson

3. A Proposed Classification of Motivations for Planetary Exploration
by Sqn. Ldr. T. J. Grant

Offers of further papers are invited. Registration forms and full details of the programme are available from the Executive Secretary.

34th IAF Congress

The 34th Congress of the International Astronautical Federation will be held in Budapest, Hungary on **10–15 October 1983.**

Theme: **COOPERATION IN SPACE**

Members of the Society wishing to present papers are asked to notify Dr. L. R. Shepherd, Chairman of the BIS International Liason Committee at Society HQ as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

Anniversary Dinner

50th Anniversary Dinners will be held at Society HQ on **21 & 22 October 1983.** See inside front cover of this issue for details.

Society Visit

MOON ROCKS

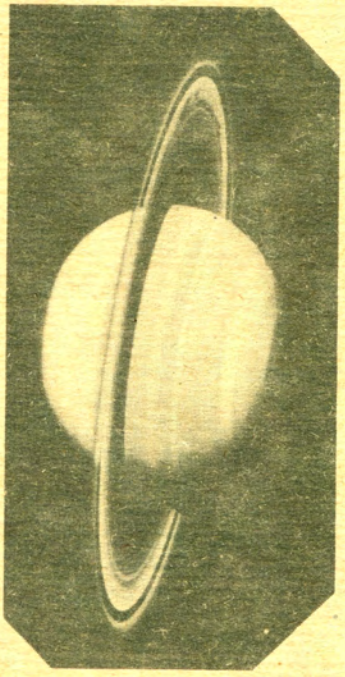
An evening visit to the City of London Polytechnic to view lunar samples and hear a short lecture will take place on **26 October 1983,** 7.00-8.30 p.m.

The number of places is limited so early application is essential.

Film Shows

THE DEPTHS OF SPACE

Man's knowledge of the Solar System has increased by leaps and bounds over the past two decades. Probes have penetrated in towards the Sun and Mercury, and Voyager 2 is now heading for distant Uranus with its retinue of five known moons.



The two parts of this programme will cover these early years of our first steps into the depths of space. Part 1, on **9 November 1983,** 7–8.30 p.m. includes:

(a) Partnership in Space: Mission Helios
(b) Mercury: Exploration of a Planet
(c) The Clouds of Venus
(d) Meteosat

Part 2, on **30 November 1983,** 7–8.30 p.m. includes:

(a) The Planet Mars
(b) Exploration of the Planets
(c) Jupiter Odyssey
(d) Rotation of Jupiter
(e) Universe

Both parts will be screened in the Society's Conference Room, 27/29 South Lambeth Road, London SW8 1SZ. Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

LIBRARY

The Library will be open to members from 5.30–7.00 p.m. on the following dates:

14 Sept., 5 Oct., 9 Nov., 30 Nov. and 7 Dec. 1983

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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SPACEFLIGHT

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OUR 50th ANNIVERSARY YEAR

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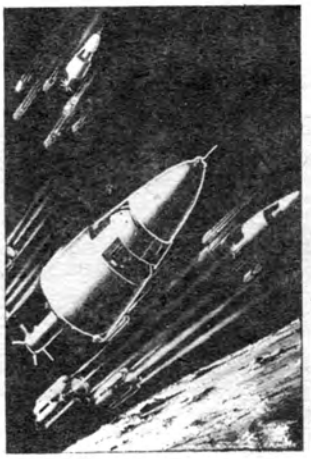
NOVEMBER 1983
VOLUME 25 No. 11

SPACEFLIGHT

A Publication of The British Interplanetary Society

VOL. 25 No. 11 NOVEMBER 1983 *Published 15 October 1983*

It is fitting that the issue marking the Society's 50th Anniversary should carry a cover picture by R. A. Smith. Smith was one of the group of visionaries who, over the 1930's and 1950's, established the Society's excellent



reputation for forward-looking studies. Our cover concept shows a 1947 atomic-powered ship landing on the Moon, while those on this page illustrate others far ahead of their time. At top is an early satellite, consisting of the top stage

of the launcher. Below that is a suggestion by Smith and Arthur C. Clarke for dropping supplies to a long-term lunar expedition. The 1950's spacecraft at the corner of the page moves further afield — to an encounter with Mars. All these ideas are described in detail in the Society's book High Road to the Moon. *The final picture, by artist Don Dixon, shows a Daedalus-type probe with the second stage separating. Just 40 years elapsed between the 1939 Moonship design (a forerunner of the 1947 version seen on the cover) and the Daedalus starship. Ahead lies an exciting range of further visionary concepts to span the next half century.*

CONTENTS

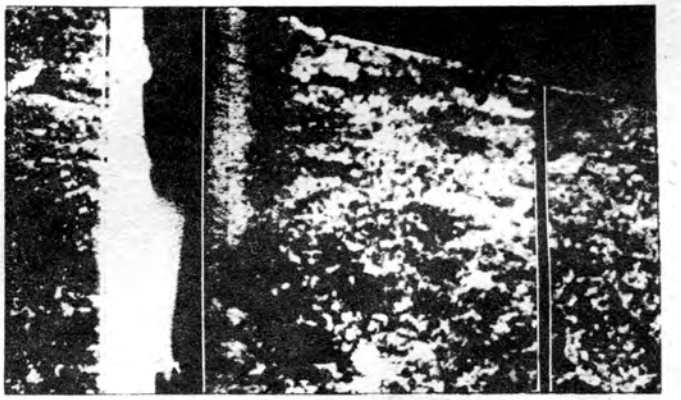
SPACE EVENTS 1933–1983	**382**
THE FORMATIVE YEARS OF THE BIS *Frank H. Winter*	**384**
MILESTONES	**402**
SPACE REPORT	**404**
SPACE COMMUNICATIONS	**408**
SPACE AT JPL *Dr. William I. McLaughlin*	**410**
THE COSMOS CALCULATOR *Nicholas L. Johnson*	**413**
THE OBJECTIVES OF SPACELAB 2 *John Bird*	**416**
NEWS FROM THE CAPE *Gordon L. Harris*	**418**
WHERE IS EVERYBODY?	**419**
FROM THE SECRETARY'S DESK	**422**
SATELLITE DIGEST — 167 *Robert D. Christy*	**424**
BIS SOVIET SPACE FORUM	**425**
CORRESPONDENCE	**426**
BOOK NOTICES	**427**

SPACE EVENTS 1933–1983

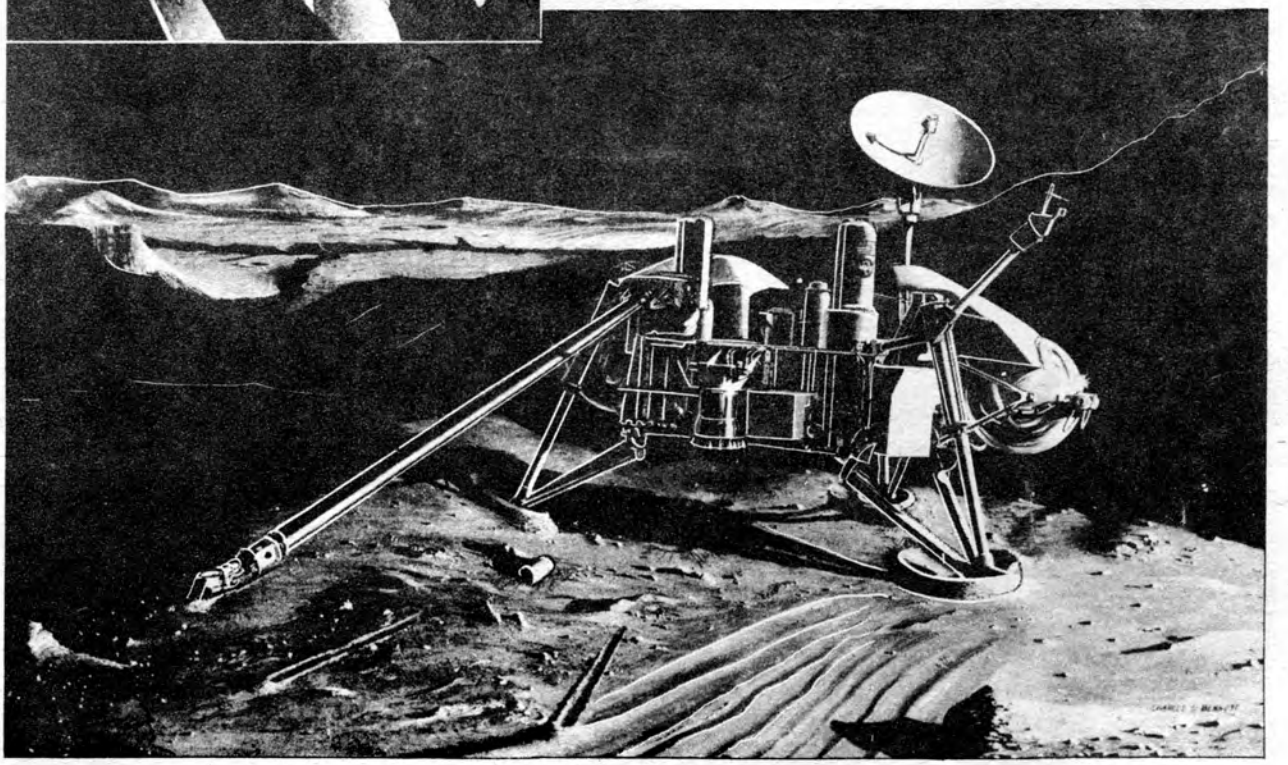
The first half century of our Society has seen the concept of space travel move from a position of ridicule to one of respect and even awe. The first 25 years of the Space Age fit quite neatly into the second half of our existence — it is something of a shock to realise that the BIS is twice as old as the Space Age itself.

The last three decades have seen the headline-events of Sputnik, Gagarin and Apollo II give way to the steady progress of the Shuttle and Salyut. Less spectacular, but equally important, have been the giant strides achieved by communications, meteorological and Earth resources satellites. Space exploration has now given way to space exploitation.

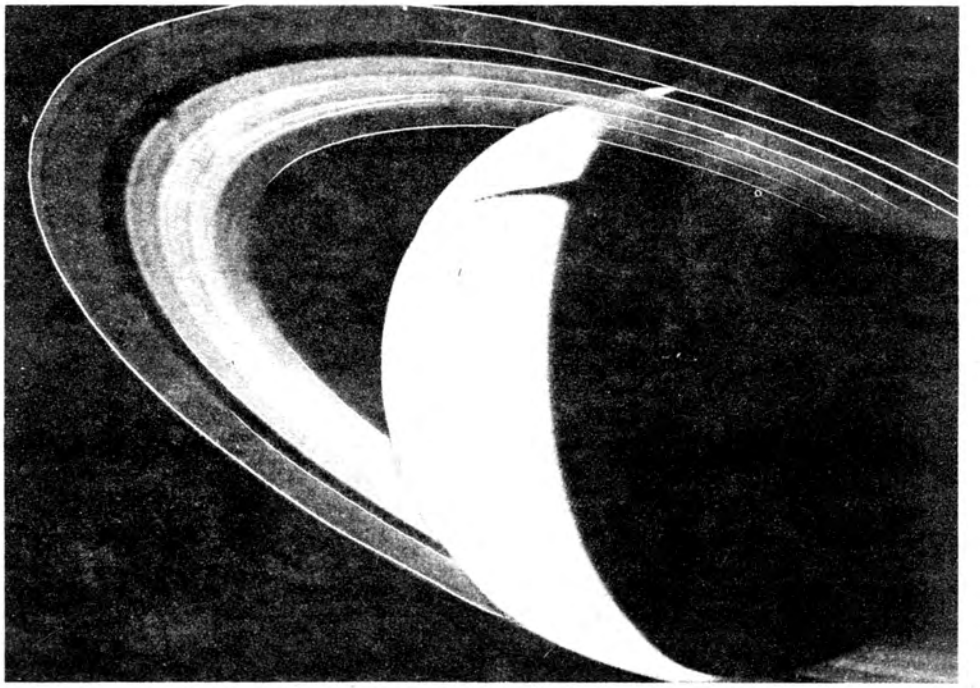
The shadows of future exciting events are already on the horizon, with the Society making its mark as man moves towards the stars.

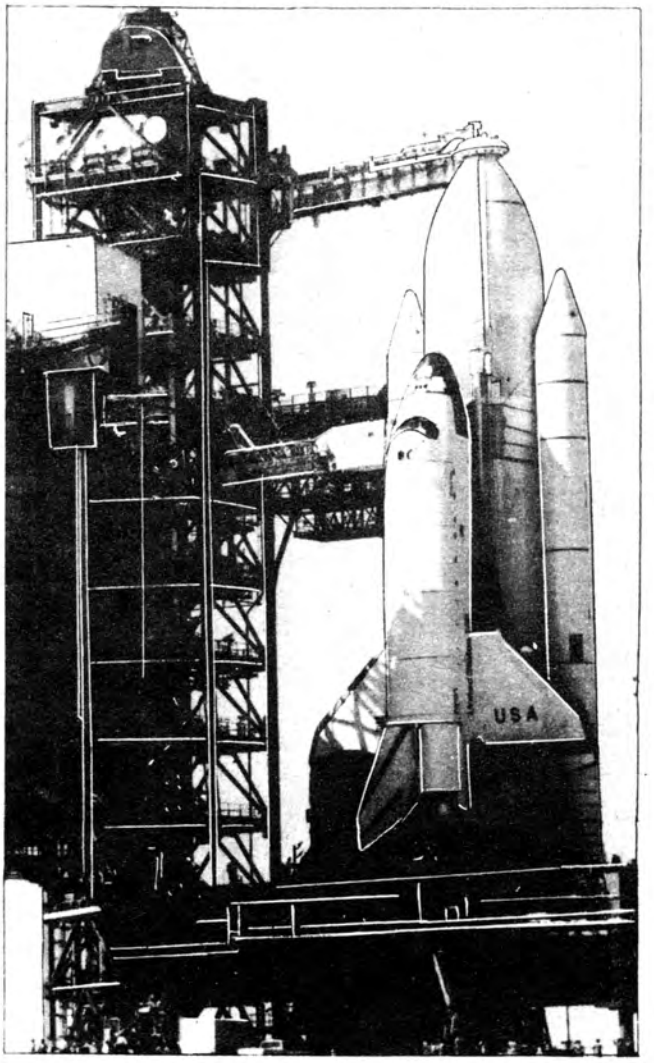


Left: Yuri Gagarin will always be remembered as the first man in space, tentatively stepping into the void where no human had previously ventured. His short, 1-orbit trip took place on 12 April 1961 when the Society was already 27 years old. Gagarin never made another space flight — he died in a flying accident in 1968. *Above:* the Soviets recorded another important first when their Luna 9 probe returned the first pictures from the surface of the Moon in February 1966. Since then our nearest celestial neighbour has been visited by Surveyors, Apollos, Lunar Orbiters and many others. Hopefully, man will return there on a permanent basis at the turn of the century. *Below:* Mars, a more distant target. Project Viking dropped two soft landers on to the Red Planet in 1976 to give us our first close up views of the planet. No positive confirmation of life resulted but we can still live in hope.

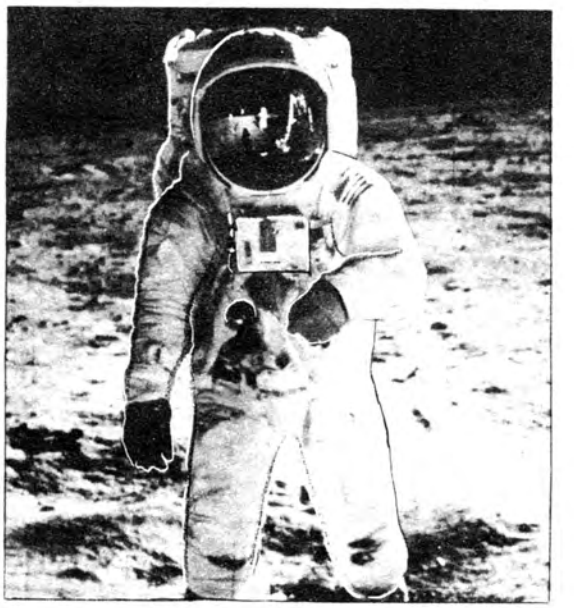


Right: the two Voyager probes revealed the beauty of Saturn and its rings in 1980 and 1981. The rings were revealed to possess unsuspected complexity, with thousands of bands, braids and 'spokes'. Voyager continues to press on towards encounters with Uranus in 1986 and Neptune in 1989. Other US planetary plans call for the Galileo probe to be launched towards Jupiter in 1986 and the VRM to Venus in 1988. Halley's Comet will be met by an international welcoming committee of no less than four probes in 1986.





Left: the launch of the first Space Shuttle mission on 12 April 1981 — exactly 20 years after Gagarin's flight — ushered in a new era of space travel. Already, the shuttle no longer commands headlines around the world as it quietly continues to take its payloads into orbit. This is as it should be: space travel no longer excites the "gee whizz" attitudes of Gagarin's day. *Below:* perhaps the most historic event of all too many people: the first manned landing on the Moon. Lunar Module *Eagle* took Neil Armstrong and Buzz Aldrin to the surface of the Moon on 20 July 1969; still within President Kennedy's declaration of landing a man on the Moon before the end of the decade. Some argue that such a project was a misdirection of resources and that establishing a permanent space station and building a reusable Space Shuttle should have come first. But who can deny the feeling of pride of having lived through those heady days during the last summer of the 1960's.



THE FORMATIVE YEARS OF THE BIS

By Frank H. Winter*

The Launching Pad

The world first became space travel conscious during the 1920's and 30's. There were several contributing factors:

(1) rapid progress in aviation, especially after Lindbergh's 1927 trans-Atlantic crossing; people began to think about flying into the stratosphere and beyond;

(2) the birth of "modern" science fiction with its stress on interplanetary stories (e.g. Hugo Gernsback's *Amazing Stories* magazine was founded in 1926 and consistently featured space flight);

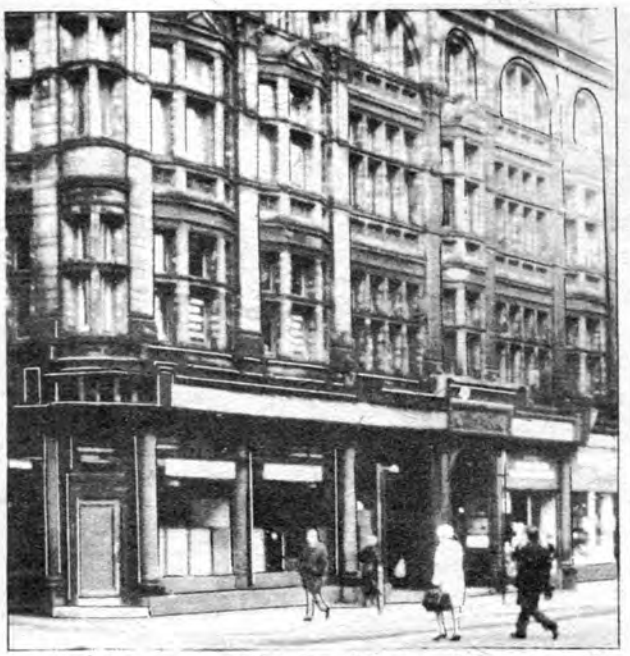
(3) Einstein's theory of atomic energy became more generally known by the 1920's (space rockets propelled by atomic energy were theorized by André Bing, Esnault-Pelterie, Goddard, *et al.* and appear in science fiction from the early 1920's);

(4) there was a universal fascination with Mars and possible life on that planet, especially during close Mars-Earth oppositions as in 1924; and

(5) scientists became more concerned with solving the mysteries of the "Heaviside layer" and cosmic rays by the 1930's (the Piccards made their much-publicised cosmic ray balloon sondes from 1931).

These influences in turn prompted the first theorists, and later, rocket experimenters, to lay the groundwork for astronautics and modern rocketry. The American physics professor, Robert H. Goddard, in particular received world-wide attention following the release of his monograph, *A Method of Reaching Extreme Altitudes*, in 1920 [1].

*Historian, National Air and Space Museum, Washington, D.C.



Site of the founding on 13 October 1933 of the BIS, in Room 15, second floor, office of H.C. Binns, accountant, No. 81 Dale St., Liverpool. Photographs taken in 1979 by Leslie Johnson, first BIS Secretary and one of the founders.

FROM LIVERPOOL TO LONDON

A 1950's picture of Phillip Ellaby Cleator, founder of the BIS.

National Air & Space Museum

Goddard advocated solid-fuel step rockets for exploring the upper reaches of the atmosphere and mathematically demonstrated that step rockets could also reach the Moon. Hermann Oberth's 1923 book, *Die Rakete zu den Planetenräumen (The Rocket to Planetary Space)*, detailed the possibility of *manned* spaceflight *via* liquid-fuel rockets and was therefore also a major if not pivotal influence upon the growing astronautics movement.

Interest in space travel reached such a peak that from the mid-1920's organisations were founded to promote the idea further, to educate the public and perhaps collect engineers and other experts to actually solve the great problems of how to achieve space flight. In Soviet Russia, theorist Konstantin Tsiolkovsky became more widely known for his contributions, as did the work of Fridrikh Tsander and others. This led to the founding of the *Society for Studying Interplanetary Travel*, or *OIMS*, in 1924 by students of the N.E. Zhukovsky Air Force Academy in Moscow. Short-lived though it was, it heralded the creation of similar groups, as the Osterreich Gesellschaft für Hohenforschung (Austrian Society for High Altitude Exploration) in 1926; the more famous Verien für Raumschiffahrt (popularly called The German Rocket Society) in 1927; the American Interplanetary Society (hereafter cited as AIS) in 1930; the various Russian Groups for the Study of Reactive Motion (GIRDs) in 1931–1932; and the British Interplanetary Society in 1933 [2].

Some crazy, Flapper-era experiments with rocket-powered cars, ice-sleighs, aircraft, trains, ice sleds and even bicycles also came to public attention *via* silent newsreels, Sunday newspaper supplements, and popular scientific press. This further excited (if not elucidated) the public mind on the potentials of the rocket. A feature movie, *Frau im Mond (Woman on the Moon)*, released world-wide in 1929 by Germany's Ufa studios also added its considerable share to the growing space flight mystique. This then, was the backdrop of the British Interplanetary Society in its formative days.

The English Scene

Surprisingly little had been done in the way of theory in space flight in England in the 1920's and 30's although it was not without its own rocket enthusiasts. In the First World War French Naval Lieutenant Yves Le Prieur came to London and succeeded in convincing the British to attach his anti-balloon rockets to some of their biplanes. Archibald Montgomery Low, later a major protagonist in the BIS story, undertook his own experiments with radio-controlled unmanned aircraft and air-to-air wire-guided rockets. Low, a prolific inventor and popular science writer, took up the cause of space flight from the 1920's. In 1924 Ernest Welch of Hull made the newspapers both in Great Britain and abroad with his horrible "death rocket" which he tried to sell to the British, French and American Armies, *albeit* unsuccessfully. (See *Science and Invention* for November 1924, p.656 and the London *Times* of 11 June 1924, p.9). Contemporaneously, Harry Grindell-Mathews, an East Yorkshireman, conceived a similarly destructive device. (See *Popular Science Monthly*, November 1924, p.40).

On the peaceful side, in 1927 British physicist Sir Charles Boys proposed to investigate lightning bolts by rocket (*Popular Science Monthly*, March 1927, p.47) and in 1927 Paul Adorian, a student of the City and Guilds Engineering College, Kensington, demonstrated before news and cameramen his model of a monorail type rocket (London *Morning Post*, 24 January 1929, p.12).

What about space flight? Interest in England was nowhere near as as intense as it was in Germany where Oberth's book had been published and where the foremost of the space societies, the Verein für Raumschiffahrt, flourished with almost 1,000 members by 1929. Perhaps one of the reasons for this lack of appreciation in Britain was the paucity of space literature *vis-á-vis* the Continent where Oberth had many disciples and imitators. To be sure, Goddard's name was known in England, prompting playwright and composer Edward P. Genn of Liverpool to write to Goddard on 18 July 1929 offering "myself to you to 'Shoot the Moon'" (i.e. to be a passenger in Goddard's alleged "Moon Rocket") [3]. But amongst the first serious discussions of space flight by Britons were remarks (rather negative ones) by David R. Pye, Deputy Director of Scientific Research of the Air Ministry in a 1930 Cambridge University lecture, "Evolution of the

A. M. Low (1887–1956), second President of the BIS. A well-known inventor and popular science writer who was one of the staunchest supporters from the earliest days.

National Air & Space Museum

The logo used on BIS correspondence in the 1930's.

National Air & Space Museum

MEMBER'S CORRESPONDENCE.

Modern Aero Engine" (See *The Aeroplane—Supplement*, 26 March 1930, p.522). Adorian, mentioned above, read a paper about rockets earlier, on 23 January 1929, before the Engineering Society of the City and Guilds College of London and repeated the paper in 1930 but it was largely extracted from Goddard's *Method of Reaching Extreme Altitudes* with an added summation of rocket stunts then being performed in Germany. More substantial and original was "Jet Propulsion for Aircraft" by Edward G. Richardson, appearing in the prestigious *Journal of the Royal Aeronautical Society* in 1931 (pp.29–36). This was followed by Dr. Herbert Chatley's paper "Rocket Theory," read on 2 May 1932 before the Society of Engineers and which dealt almost exclusively with the rocket as a means of exploring outer space. (See *Transactions of the Society of Engineers*, 1932, pp.53–73). This talk was also reported in *The Times* of 3 May 1932 (p.7) and touched off a lively discussion amongst those present.

The Science Fiction Connection

Yet these discussions were not enough to spark a drive to start a space society here. What, then, were the real roots of the BIS? As in its American counterpart, the American Interplanetary Society, some early members were influenced by science fiction [4]. Science fiction was a link between the two organisations. Evidence of this is found in the readers letters columns of American science fiction magazines like *Wonder Stories* and in the surviving early BIS-AIS correspondence. In the March, 1931 issue of *Wonder Stories* is a letter from Walter H. Gillings (later a prominent BIS member) who had helped to start the science fiction club called the Ilford Science Literary Circle. Gillings, whom we are to encounter later, was "extraordinarily interested and [an] intensely enthusiastic supporter of science fiction since I first came into contact with your earlier publications [*Amazing Stories*]." *Wonder Stories* also published notices about the AIS which Gillings and fellow British science fiction enthusiasts could not fail to see. Thus, Gillings came close to forming his own BIS group *via* this literature. In fact when the BIS was eventually formed it, too, was noted in the magazine's pages. Also, several British science fiction fans were led to join the BIS through *Wonder Stories* [5].

Full credit for actually initiating the BIS of course goes to Philip Ellaby Cleator. Cleator was then a 23 year old structural engineer from Wallasey, Cheshire whose interest was first aroused in the mid-1920's by a short documentary film about radium of which one proposed application was as a nuclear fuel to convey man to the planets. The closing scene was of a rocket-like vehicle heading into space trailing a radioactive glow. On 10 August 1931 he wrote to AIS Secretary Charles P. Mason (who also happened to be *Wonder Stories'* Associate Editor): "Dear Sir, Quite by accident I came across a short description of the American Interplanetary Society in a magazine from your country [this was almost certainly *Wonder Stories* or at least another science fiction magazine] . . . I shall be greatly obliged to receive from you full particulars together with the necessary membership forms. Interplanetary travel constitutes a problem of great interest." Clearly

E. J. Carnell (1912–1972) a prominent early member and a noted Science Fiction writer. He is shown in 1940 outside 16 Rockville Road, Liverpool, selling off his stock of *Science Fiction Service* because of the outbreak of WW2.

Photo by Leslie Johnson

Cleator was introduced to the idea of an interplanetary society through the common bond of the science fiction "pulps" [6].

But Cleator did not start the BIS right away after his letter to Mason. Perhaps this was because the AIS was in its own infancy and could report little progress. He was also heavily involved with his own business, run with two colleagues, the Scientific Research Syndicate which undertook "chemical, physical and electrical researches," including "radio and television devices", and also in his father's business as structural engineer. He also went through an educational phase in the then new "science" of astronautics, eagerly clipping all the space articles that came his way [7]. One of Cleator's earliest lessons was that there was both apathy about space flight in his own country and also no shortage of sarcastic critics who often doubted the sanity of those espousing the cause.

The BIS Is Launched

P. E. Cleator continued corresponding with AIS Secretary Mason. In a sense, however, another American also helped prompt Cleator to start his own society. The other man was William A. Conrad, Assistant Professor of Mathematics of the U.S. Naval Academy at Annapolis, Maryland. In August 1933 *The Liverpool Echo* published Conrad's predictions of rocket flight to the Moon. The article was typically generalised for the period. Cleator himself had written a similar piece (perhaps his first space writing) which appeared in the January 1933 issue of the British magazine *Chambers's Journal*. What most affected Cleator was that Conrad was an American and that all the publicity

about space flight seemed to emanate from the US, Germany, Russia, and even France, but never England [8]. So far as he knew, his *Chambers's* article ellicited no surge of interest in the subject in England and was the only British-originated space article he had seen (with the exception of Chatley's paper.)

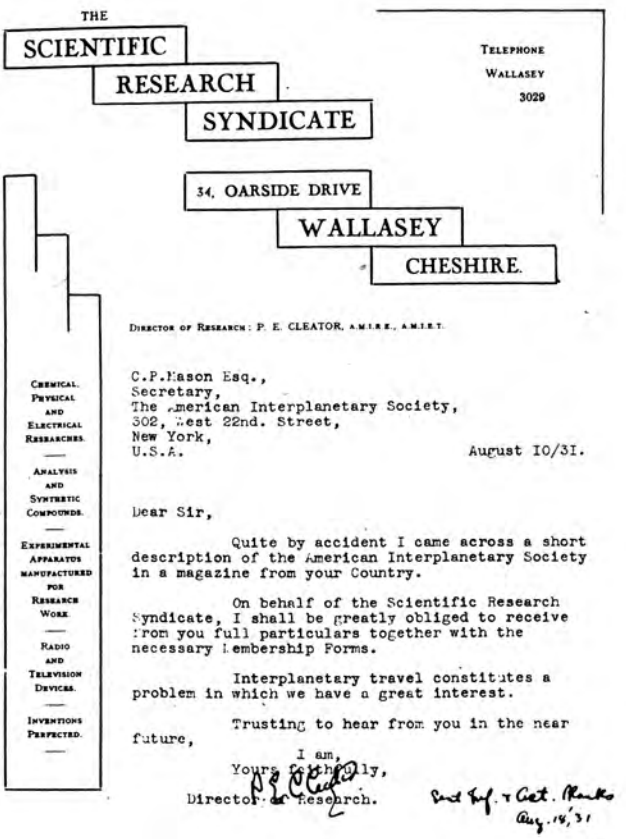
On 8 September 1933 the *Liverpool Echo* printed his reaction to the Conrad piece. Cleator also offered a plea. He expressed admiration for the Americans "who had made tremendous strides . . . towards space travel." "Three years ago," he was compelled to add, "a group of interested experimentalists founded the American Interplanetary Society . . . England is years behind . . . Before me as I write is a letter I have recently received from Mr. C. P. Mason, Secretary of the American Interplanetary Society. He says: '. . . there is a field for a British (Interplanetary) Society, *which we hope to see organised at the earliest moment.*' The italics are mine [Cleator's]. The immediate formation of a British Interplanetary Society is imperative, if we are to keep pace with other progressive nations . . . Perhaps those interested will communicate with me?"

Cleator's *Liverpool Echo* letter attracted almost nobody save, fortunately, for N. E. Moore Raymond, Manchester correspondent for the London *Daily Express*. Moore Raymond, who became both a space and science fiction convert, visited him, resulting in a splashy story on page one of the 20 September 1933 issue of the *Express* announcing Cleator's desire to start an interplanetary group:

"NEWS-REEL OF THIS CRAZY WORLD TO-DAY Arms And the Frenchman: A King's Betrothal: Atlantic Rocket TO AMERICA IN AN HOUR Cheshire Man Plans To Turn Visions Of To-day Into To-morrow's Way Of Travel."

Cleator received several enquiries but felt it best to hold a special meeting at his home at 34, Oarside Drive, Wallasey, Cheshire, to decide what to do further. Thanks to the records of one of the people present, the late Leslie J. Johnson, we can date the first pre-BIS meeting to 8.00 p.m., Thursday, 28 September 1933. Johnson himself, who had earlier formed his own science fiction club (The Universal Science Circle), subsequently became the BIS' first Secretary. The half dozen or so guests at the Cleator residence were treated to an exhibit of a rocket motor made by their host [9].

Johnson brought his friends, his office mate James A. Free, Jr., and former Universal Science Circle member Colin Henry Askham, an amateur radio ham who became the first Vice President. Percival Norman Weedall, another strong science fiction fan, was also present. Following some other preliminary gatherings elsewhere, the BIS official inaugural meeting was held at 7.00 p.m. on the inauspicious date of Friday, 13 October 1933 in Room 15, Second Floor, No. 81 Dale Street, Liverpool, though only five turned up. This place was the accountant's office of the father of Herbert C. Binns, Jr., a long time friend of Cleator's. The official founders were, besides Cleator, Johnson, Free, Askham, Weedall and Binns, J. Toolan, James Davies (a fellow radio amateur of Askham), Thomas McNab, E. Roberts, and Miss A. E. Heaton. The only woman of the founders was named Treasurer. Miss Heaton



THE SCIENTIFIC RESEARCH SYNDICATE

TELEPHONE WALLASEY 3029

34, OARSIDE DRIVE
WALLASEY
CHESHIRE.

DIRECTOR OF RESEARCH: P. E. CLEATOR, A.M.I.R.E., A.M.I.E.T.

CHEMICAL, PHYSICAL AND ELECTRICAL RESEARCHES.
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C.P.Mason Esq.,
Secretary,
The American Interplanetary Society,
302, West 22nd. Street,
New York,
U.S.A.

August 10/31.

Dear Sir,

Quite by accident I came across a short description of the American Interplanetary Society in a magazine from your Country.

On behalf of the Scientific Research Syndicate, I shall be greatly obliged to receive from you full particulars together with the necessary Membership Forms.

Interplanetary travel constitutes a problem in which we have a great interest.

Trusting to hear from you in the near future,

I am,
Yours faithfully,
P. E. Cleator
Director of Research.

Sent Sup. + Cat. Blanks Aug. 14, '31

Letter from Cleator 10 August 1931 to C. P. Mason of the AIS. The original is in the G. Edward Pendray collection, Princeton University.

soon became Mrs. A. E. Weston, however, and quickly disappeared from the BIS rolls though she was granted an Honorary Fellowship—the Society's first lady Fellow [10]. R. S. Chambers of *Chambers's Journal* and N. E. Moore Raymond were accorded similar honours for their publicising efforts. The latter now included the BIS on his reporter's "beat".

The Journal Started

In the 18 October 1933 issue of the *Express* Moore Raymond announced that the headquarters of the fledgling organisation were to be at Oarside Drive, Wallasey, Cleator's home. Here too, Cleator was quoted as "building the first rocket car to be made in Britain . . . The next thing to do is to establish a British 'spaceport' . . . which will include a fully equipped laboratory for the use of members engaged in research." Both these ambitions were never realised. More practical was Cleator's plan for "arranging for the establishment of branches throughout the country." "Each branch," Cleator continued, "will concentrate on some particular phase of the problem to prevent overlapping. The first thing we must do is to make the rocket motor practicable, because no other known motor is of any use for space travel." BIS branches were, of course, later formed but for reasons which

(American Rocket Society)
ROCKET NO. 1 OF THE AMERICAN ROCKET SOCIETY
This rocket reached a speed of 700 miles per hour in successful trial flights last fall (1935). Left, G. Edward Pendray, President of the American Rocket Society. Right, John Shesta, Engineer of the Society

ROCKETS
THROUGH SPACE

THE DAWN OF INTERPLANETARY TRAVEL

By P. E. Cleator

SIMON AND SCHUSTER · NEW YORK

1936

Britain's first Science Fiction magazine appeared in 1934 and regularly featured BIS news.

will soon unfold, the Society could not take up any actual experiments.

Society news also appeared in *Practical Mechanics* magazine (announcing, for example, fortnightly meetings at 81 Dale Street). But every proper Society has to have its own journal. "Such a publication, it seemed to me," Cleator recalled years later, "would serve not only to retain the interest of existing members, but would provide something tangible to send to prospective ones. The need was not disputed . . ."

To save the Society money, Cleator almost fully paid for the printing of the journal himself. It was nearly a one-man show. P. E. Cleator compiled, edited and illustrated it. Little known is that member Joseph Laffan of Dublin also contributed 15 shillings toward the publication cost. A suitably futuristic cover was needed for the futuristic Society; consequently, Cleator announced an illustration contest. The names of the competing artists were anonymous up until the judging. Then it was revealed that Cleator himself had won the one guinea prize!

The first issue of the *Journal of the British Interplanetary Society* appearing in January 1934, was sparse: six pages which included a mention of Cleator's article, an advertisement of *Chambers's*, a description of the BIS and its membership requirements, and a lengthy Cleator editorial titled "Retrospect and Prospect." That same month Cleator flew to Germany on a personal trip, specifically to meet Willy Ley and visit the Raketflugplatz, then in charge of Rudolf Nebel, in the Berlin suburb of Reinickendorf. He took the opportunity to confer with German Rocket Society (VfR) officials in Berlin. He was in Germany ten days, two of which he spent with the rocketeers [11].

Mission to Germany

When he visited the VfR that organization was actually in a state of collapse. Cleator could not have come at a worse time. Cleator was not told of all of the internal political events and monetary problems that had torn the German group asunder, but his hosts were gracious. Despite the VfR's troubles, Rudolf Nebel showed Cleator the VfR's once proud "*Raketenflugplatz*" (Rocket Flying Place) testing field. But little wonder that all Cleator remembers seeing were "delapitated buildings." Cleator saw no rocket firings of course and he also missed seeing 20-year old Wernher von Braun by three or four months; von Braun, along with other VfR leading experimenters, had joined the German Army's secret rocket programme that ultimately led to the infamous V-2 which later wrought so much grief upon London, Antwerp and other cities during World War II. Following the sightseeing of the Raketenflugplatz, Cleator privately met Willy Ley, the VfR's recently resigned Vice-President.

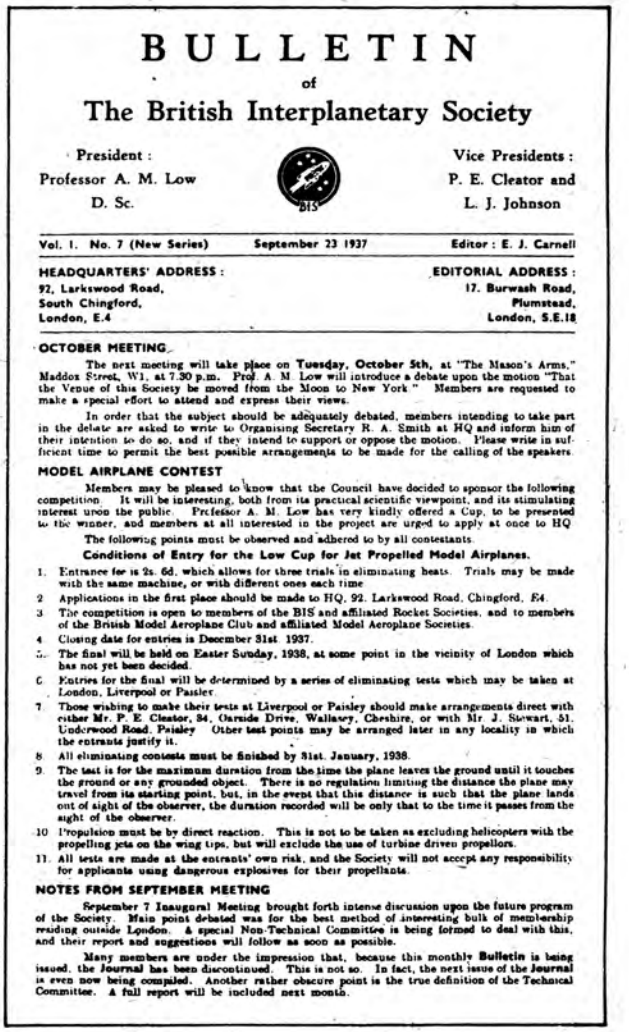
One positive thing that Ley could do was give his English guest a list of names and addresses of rocket experimenters around the world, including Britain's own A. M. Low. Cleator was also able to meet other

German rocket or space travel enthusiasts, such as the chemists Richard and Raymond Thiele and to confer honorary BIS Founder Fellowships upon them as well. BIS Fellowships thus grew into a distinguished roster which enhanced the BIS name, even if these individuals did not always directly contribute to BIS work [12]. Ley and Low were made Fellows, followed by the famous Russian astronautical publicists Yakov Isidorovich Perelman and Professor Nikolai Alexeyevich Rynin; the great French aviation and astronautical pioneer Robert Esnault-Pelterie; the Austrian space travel theorist Baron Guido von Pirquet and others.

Cleator's German trip also helped impress upon his mind the strong visual impact of the motion picture *Frau im Mond* (mentioned above) with its dramatic, realistic space rocket (designed by Professor Oberth) and launch sequences to the Moon. The VfR's headquarters were decorated with a model of the *Frau im Mond* spaceship and a blow-up of the ship in flight adorned the wall. Cleator was also aware of the success of the film in generating new members for the AIS back in 1931. Upon his return to England he went to great lengths to locate a threatre which would similarly show the movie to BIS membership and potential joiners. One problem was, he wrote at the time, that "Sunday cinema shows in England are looked upon as the world's greatest sin." The movie of course could only be shown on this day so it would not conflict with the theatre's normal show. Cleator finally found a willing "liberal" cinema manager. He then contacted "a number of newspaper editors" to back him up with publicity. When this was done he discovered to his consternation that no copies of the film were to be had in the country!

If this propagandistic coup failed, other means of publicity were at hand. Britain's first science fiction magazine, *Scoops*, appeared in February (1934). As *Wonder Stories* and other American science fiction periodicals contributed much to the space travel movement due to their wide, pro-interplanetary travel readership, then *Scoops* might serve as a similar vehicle in England. From *Scoops* issue of 24 March 1934, Cleator's name and BIS news began to appear fairly regularly. Cleator's entry into *Scoops* began as a debate. Noted British astronomer and popular science writer Sir James Jeans opened with a somewhat critical article based on his lectures "Shall We Ever Travel to the Planets?" Sir James was fearful of the effects of the "meteor menace," radiations, and the mysterious Heaviside layer. Cleator, a great optimist and wit, replied with an affirmative "We *Shall* Travel to the Planets," ending with the promise that when Alpha Centauri is reached the Society's name will be changed to The British Interstellar Society.

In the 5 May issue of *Scoops* appears the first of Cleator's weekly column, "To the Planets." *Scoops*, however, did not last out the year and succumbed to heavy competition from similar, but non-space weekly tabloids. In the meantime, Cleator was able to have another of his science fiction stories, "Martian Madness," published in the March 1934 issue of *Science Wonder*, a descendant of the magazine that had got him started. Another magazine, *Armchair Science*, through the courtesies of its editor, A. M. Low, also



BULLETIN

of

The British Interplanetary Society

President : Professor A. M. Low D. Sc.

Vice Presidents : P. E. Cleator and L. J. Johnson

Vol. 1. No. 7 (New Series) September 23 1937 Editor : E. J. Carnell

HEADQUARTERS' ADDRESS : 92, Larkswood Road, South Chingford, London, E.4

EDITORIAL ADDRESS : 17. Burwash Road, Plumstead, London, S.E.18

OCTOBER MEETING

The next meeting will take place on **Tuesday, October 5th,** at "The Mason's Arms," Maddox Street, W1, at 7.30 p.m. Prof. A. M. Low will introduce a debate upon the motion "That the Venue of this Society be moved from the Moon to New York." Members are requested to make a special effort to attend and express their views.

In order that the subject should be adequately debated, members intending to take part in the debate are asked to write to Organising Secretary R. A. Smith at HQ and inform him of their intention to do so, and if they intend to support or oppose the motion. Please write in sufficient time to permit the best possible arrangements to be made for the calling of the speakers.

MODEL AIRPLANE CONTEST

Members may be pleased to know that the Council have decided to sponsor the following competition. It will be interesting, both from its practical scientific viewpoint, and its stimulating interest upon the public. Professor A. M. Low has very kindly offered a Cup, to be presented to the winner, and members at all interested in the project are urged to apply at once to HQ.

The following points must be observed and adhered to by all contestants.

Conditions of Entry for the Low Cup for Jet Propelled Model Airplanes.

1. Entrance fee is 2s. 6d. which allows for three trials in eliminating heats. Trials may be made with the same machine, or with different ones each time.
2. Applications in the first place should be made to HQ, 92, Larkswood Road, Chingford, E4.
3. The competition is open to members of the BIS and affiliated Rocket Societies, and to members of the British Model Aeroplane Club and affiliated Model Aeroplane Societies.
4. Closing date for entries is December 31st 1937.
5. The final will be held on Easter Sunday, 1938, at some point in the vicinity of London which has not yet been decided.
6. Entries for the final will be determined by a series of eliminating tests which may be taken at London, Liverpool or Paisley.
7. Those wishing to make their tests at Liverpool or Paisley should make arrangements direct with either Mr. P. E. Cleator, 84, Carside Drive, Wallasey, Cheshire, or with Mr. J. Stewart, 51, Underwood Road, Paisley. Other test points may be arranged later in any locality in which the entrants justify it.
8. All eliminating contests must be finished by 31st. January, 1938.
9. The test is for the maximum duration from the time the plane leaves the ground until it touches the ground or any grounded object. There is no regulation limiting the distance the plane may travel from its starting point, but, in the event that this distance is such that the plane lands out of sight of the observer, the duration recorded will be only that to the time it passes from the sight of the observer.
10. Propulsion must be by direct reaction. This is not to be taken as excluding helicopters with the propelling jets on the wing tips, but will exclude the use of turbine driven propellors.
11. All tests are made at the entrants' own risk, and the Society will not accept any responsibility for applicants using dangerous explosives for their propellants.

NOTES FROM SEPTEMBER MEETING

September 7 Inaugural Meeting brought forth intense discussion upon the future program of the Society. Main point debated was for the best method of interesting bulk of membership residing outside London. A special Non-Technical Committee is being formed to deal with this, and their report and suggestions will follow as soon as possible.

Many members are under the impression that, because this monthly **Bulletin** is being issued, the **Journal** has been discontinued. This is not so. In fact, the next issue of the **Journal** is even now being compiled. Another rather obscure point is the true definition of the Technical Committee. A full report will be included next month.

afforded the BIS generous coverage. Typical was Cleator's piece in the July 1935 issue, "The Rocket and the Vacuum." It is not surprising that, as in America, the early leaders of the British space travel movement were also faced with the task of educating a disbelieving public that the rocket really could work in the vaccuum of space.

Quest for Experiments

BIS growth was modest. The number of actual founders has not been adequately recorded but seems to have been at least 11. With initial "Founder Fellowships" it amounted to 15. By May 1934, the number was 40. There was a certain levelling off so that by 1940 the BIS climbed to about 100. Consequently, the collective fiscal resources were very meager during these years, with hardly anything for experimentation. The Society was fortunate enough that the second and third issues of the *Journal* were printed gratis, anonymously, by the printer John Moores of Brownlow Street, Liverpool. Otherwise the BIS could rely only upon the two guineas per annum membership fee which could be paid quarterly "by arrangement." Associate memberships, for those under 21, which included Cleator's right-hand man, Secretary L. J. Johnson, was five

The earliest known photo of the BIS, taken on 7 February 1935 in the Hamilton Cafe, Liverpool, during the visit of Willy Ley (centre, in glasses) who is shown purportedly discussing space travel plans with the membership for the benefit of the press — but the plans he holds is a blank sheet of paper! To Ley's right is Vice-President C. L. Askham. Secretary L. Johnson is second on his left. P. E. Cleator is on far right. The others are, left to right: James A. Free Jr., James Davies (upper left), Miss Eileen Hastie (who later married Colin Askham), and Miss Nora Bellew, to Ley's left. Photo and news story appeared in *The Daily Graphic, Daily Sketch* and *Sunday Graphic* 10 February 1935. Courtesy, P. E. Cleator.

shillings per annum. Yet "No one is more eager than I am to organise and to begin our share of experimental work," Cleator told his members.

The visit of German mail rocket experimenter Gerhard Zucker to England further excited the BIS President into wanting to experiment. But Herr Zucker was no space man. He purposely came to demonstrate and promote his terrestrially-bound mail-carrying rocket at the Third International APEX (Air Post Exhibition) held at London's Royal Horticultural Hall from 7–12 May 1934. Cleator made a special journey to London where, for the first time, he met Low. Both went to the Hall but delays prevented Zucker from getting any of his much feted projectiles off the ground. Cleator and company saw the "inventor," but the invention (which was not original) was hardly the forerunner of a spaceship. Zucker's rockets were propelled by ordinary solid fuel, probably gunpowder. In fact Herr Zucker had very bad luck with them in Britain that year. One rocket was blown from its path from the Lymington (Hants) golf course and landed in deserted Pennington Marshes instead of the Isle of Wight where it was supposed to; another ended in a terrific explosion at Scarp, Scotland, scattering hundreds of letters all over the beach. Interestingly, Charles Bein, described as "a staunch supporter of the Society from its very earliest days," assisted the German Zucker [13].

Another inspirational source towards BIS experimenting was the work of the American Interplanetary Society reported in *Wonder Stories* and that Society's own bulletins. On 20 February 1934 G. Edward Pendray, Vice-President of the American group, sent Cleator a letter of congratulations upon the formation of the BIS. This communication also marked the beginning of a 40+ year correspondence exchange and yet another conduit of information to the BIS about experiments [14]. "The British Society is quite young," Cleator told his new American friend in his reply of March 5th. "Quite frankly, as regards co-operation, we have little to offer in return just at the moment, except an earnest desire to further the science of rocketry . . . we are badly in need of funds. We have, of course, tried to interest various people who could help with money, so far without success. The Government, needless to say, is hopeless. The Secretary of State would not even see me. The only satisfaction that could be obtained was a remarkable letter which I intend to publish in the next issue of the Journal."

This remarkable letter was in fact from the Under-Secretary of State who followed "with interest any work that is being done in other countries on jet propulsion, but scientific investigation into the possibilities has given no indication that this method can be a serious competitor to the airscrew-engine combination. We do not consider that we should be justified in spending any time or money on it ourselves." As later BIS Members well know, this was certainly not to be the last instance of British Governmental apathy towards rockets and space exploration.

The matter of experimentation rested for a while. At about this same time, the British inventor, Harry Grindell-Mathews, was again caught up with rocket fever as there seems to have been a lapse in his rocket work since 1924. At any rate, Cleator met him in London on 26 July 1934 on his way to another trip to Germany. Grindell-Mathews had already been made a BIS Fellow. Cleator was knowledgeable in chemistry (he had his own laboratory) and the two talked about propellants. But Grindell-Mathews turned once more to making rockets for war. Cleator would have none of this even though Grindell-Mathews offered the use of his own extensive laboratory on his Tor Cloud estate at Mynydd-y-Gwair in Wales, and almost unlimited financial resources in exchange for Cleator's assistance. The BIS President stood on his principles and sought only to develop the rocket for the peaceful exploration of space, even if this meant that without money its realisation for the present and foreseeable future would be impossible.

The Cleator-Pendray-Ley Circle

For the time being, Cleator was content with simply getting the Society and himself noticed, by lecturing and writing. The 6 July 1934 Minutes record that he lectured on "Interplanetary Travel" at the Round Table Club, Birkenhead, and "had been asked about a lecture

before the Rotary Club in the near future." In Germany, the 30 June issue of *Das Neue Fahrzeug (The New Vehicle)*, the organ of the VfR's successor, the "E. V. Fortschrittliche Verkehrstechnik", (Registered Society for Progress in Traffic Technics), carried his lead article "Die Raketenbewegung in England" ("The Rocket Movement in England"). There was now also the customary exchange of Fellowships, the previous issue of *Das Neue Fahrzeug* naming Cleator as their Society's new representative in Britain. This was through the courtesy of Willy Ley who, upon the final collapse of the VfR, helped establish the new German group. Pendray was also accorded a Fellowship [15]. A true sort of fellowship did in fact develop. It manifested itself in a close correspondence between Pendray in the States, Cleator in Britain, and Ley in Germany. The three, all of like minds, also sought to internationalise the space travel movement by proposing an international space travel society. But 1934 was not the year to do it. None of the principles had any money nor adequate manpower so the most they could accomplish was offering exchanges of their respective journals to their memberships. A single journal for all the English-speaking societies was also contemplated. Cleator also imaginatively suggested utilising the amateur radio talents of BIS founders Colin Askham and James Davies to communicate with space enthusiast radio amateurs in the US, but this idea too never materialised. Ley for his part was barely eking out a living by lecturing on space flight and found the newly installed Nazi regime not at all to his liking. Private rocketry experiments became banned. Soon, with Cleator's help, Ley would be leaving Germany for good.

In England the BIS faced two minor crises during the latter part of the year. Both were easily resolved. The membership had grown to such proportions that the meetings in the Dale Street offices were becoming too crowded and warm! The meetings from 5 October were thus moved first to Leslie Johnson's home at 46 Mill Lane, then to the Hamilton Cafe (also called McChie's Cafe) at 56 Whitechapel. This place, with its "absurdly cheap" meals, served as the regular BIS meeting spot until the Society's move to London in February 1937. The other problem was member James Godwin Strong's reccommendation that the Society change its name, following the American example, by calling themselves the British Rocket Society. Strong thought this less "Amazing Storyish" title was bound to attract more members. Leslie Johnson, in his letter of 17 November 1934 to Pendray, reported with obvious satisfaction "that our members are almost unanimously in favour of the present title. Their main arguments are that the word "Rocket" will tend to narrow down the field of research, and also the activities of the Society, which, at present, embrace Astronomy and Radio as well as Rocketry." In fact, according to the new mimeographed BIS *Bulletin* that first appeared in October, Colin Askham was in charge of the "Radio Section of the Society" and with his friend Davies was constructing a transmitter to explore ultra short-waves with future outer-space communications in mind.

Meanwhile, Phil Cleator had his own concerns late that year. To his friend Pendray he confided, "I am flat broke . . . Every cent I had has gone in the BIS". He had wanted to come to the US but this was now out of the question and he was forced to hang onto his father's business as best he could. Secondly, Willy Ley sought his help in leaving Germany under a pretext that he (Ley) was only going on a brief holiday. Pendray's aid was enlisted too. After much confusion of missed deadlines and altered schedules, Ley reached London on 6 February 1935 with 10 Marks (then about $2.50) in his pocket. From there he continued to Liverpool and Wallasey to see Cleator. His British host notified the press in order to turn the occasion into additional publicity for space travel [16]. Ley was entirely agreeable to this. Consequently, *The Liverpool Echo* of **8** February 1935 ran the story of Ley's visit on their front page with the banner headlines "When Rocket Carrier Succeeds—US to England in 30 Minutes—Rocket Pioneer in Liverpool—Jules Verne Touch." Reporters from *The Daily Graphic*, *Daily Sketch* and *Sunday Graphic* were also present with a photographer for Ley's talk before a few BIS regulars in The Hamilton Cafe. The results were pictures in those papers showing Ley intently looking over his "plans" with his English listeners, explaining to them how Moonflight might be accomplished. The irony was that the paper was blank foolscap!

Ley returned to London shortly thereafter, then sailed for America where he became Pendray's guest until establishing himself as a permanent US resident. Willy Ley's subsequent career as a successful lecturer and prolific writer on space flight is, of course, well known to old time BIS members.

Publication Troubles

In the same month of February 1935, there appeared a new BIS publication, though it bore a January date: *The New Columbus*, a mimegraphed 20+ page compendum of chatty BIS news and philosophical tidbits which was meant to bridge the gap between the quarterly *JBIS* and the less substantial monthly *Bulletin* [17]. Since its last issue in October 1934, the future fate of the Journal was in fact in doubt. Its printing was too costly for the number of members then on the rolls so the BIS governing Council decided to purchase their own duplicating machine and discontinue, "at least temporarily," the printed Journal. BIS Secretary Leslie Johnson, who had edited the *Bulletin*, co-edited *The New Columbus* with a new member from Liverpool, Eric Frank Russell, later to become one of Britain's major science fiction authors. "Coming Features" for the next *New Columbus* were advertised in the opening number of this magazine, including an article by another new member and future science fiction great, Arthur C. Clarke. Clarke was to write "The Problem of Mars." But neither Clarke's article nor succeeding copies of *The New Columbus* appeared. The Council was not impressed with the style of *Columbus* and thought it too "flippant" to represent what they believed were the makings of a learned society. *The New Columbus* was at once abolished.

This led to another publications dilemma. The Council was compelled to distribute notices to the membership that the matter of publications was to be taken up in a special session. Yet for six months the Society was without any publication until the Journal re-surfaced again (once more financed in part by Cleator)

in May 1935. This issue also announced the start of the BIS Research Fund and Experimental Committee. This idea Cleator borrowed from his American friends (i.e. *via* Pendray) in which a special account was opened with donations from members for the purpose of experimentation. (Apart from membership dues, the early BIS revenue came from the sales of members' notepaper or stationery, with a futuristic emblem.) Cleator's printing of a Pendray letter which he titled "Why Not Shoot Rockets," appearing in the Journal for October 1935, further pointed the way to potential BIS experimentation with limited funds. Here Pendray detailed how the American Interplanetary Society cut corners and built their first rocket for a grand total of $49.40. Perhaps the BIS could do the same. Some donations did come in, from members Francis H. P. Knight and P. E. Hetherington for example, but alas, the money was still miniscule. But then, these were the lean years of the great world-wide Depression. Later, donations were "suggested" at five shillings.

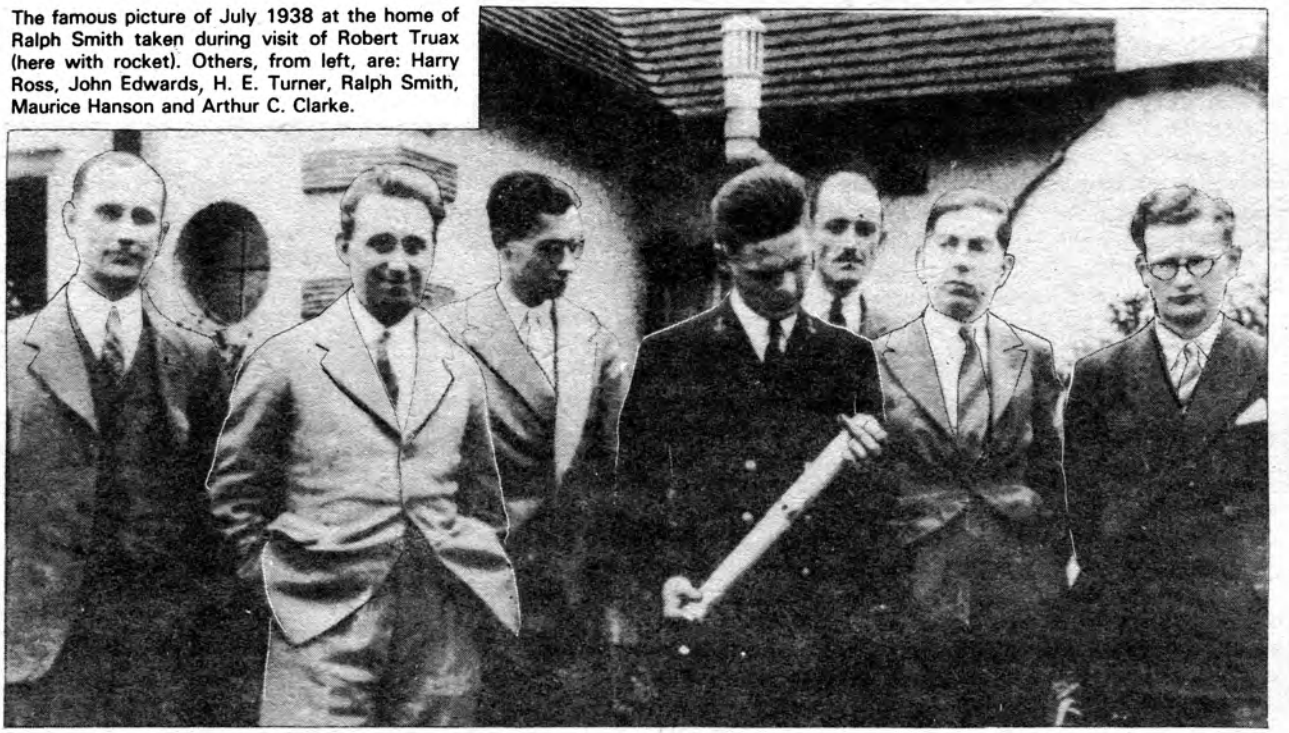
The BIS Meets the Guy Fawkes Law

"In this country at least," wrote Cleator to Pendray on 14 December 1935, the Pendray article "has created a very favourable impression. In the meantime you are left holding a bag of letters, containing requests about how to experiment!" In fact one BIS member did come forward with his own plans for a liquid-fuel rocket. This was Ralph Morris from London. Then Cleator received "some rather disturbing news." He explained it in his letter of 10 March 1936 to Pendray: Morris, he said, "sent his plans etc. to me, and between us we evolved a fairly decent design. He promised to let me have a full report in due course, and meanwhile set about the task of construction. The next I heard from him was a long letter to say his experiment had been prohibited by the Government! . . .. Experimentation with rockets was virtually forbidden anywhere in England!" The BIS had at last encountered the Explosives Act of 1875, popularly known as the Guy Fawkes Law. This legislation, which dated back to the 17th century with newer amendments, forbade private (i.e. non-commercial) experimentation of certain specified explosives and pyrotechnics, including rockets [18].

Cleator launched a vigorous counter-attack to overthrow the law. Wherever and whenever he could he lashed out against it. He took his case to the Home Office, spoke to MPs, attempted to get it discussed in Parliament, wrote vociferous articles and delivered fiery speeches. It was to no avail. The law was the law and has never been overturned to this day. The year 1936 thus opened with a promise of real experimentation but was then immediately and utterly dashed. In point of fact, private rocketry *was* permitted, but only under the very strict rules of the 1875 law in which prior notice had to be given, the project had to be approved by the local authorities, etc., etc. Even then, this only applied to the smallest *powder* rockets whereas the Home Secretary was very adamant that absolutely no liquid rockets were permitted, effectively eliminating any experiments comparable to those of the American Rocket Society (as the American Interplanetary Society became) and the old VfR. The viability of the BIS itself seemed threatened as did the whole space travel movement in Britain.

Fortuitously, as the same time as Cleator's discovery of the frustrating injunction, his book *Rockets Through Space* was released by the publishers Allen and Unwin. This rekindled the sagging spirits of the Society and gave added impetus to the world-wide space travel movement in general. Contrary to what some people claim, it was not the first book in the English language on the subject; in England Charles C. Philp produced *Stratosphere and Rocket Flight* (first English edition)

Inaugeral meeting of the London branch of the BIS, 27 October 1936 at A. M. Low's offices in Piccadilly. Photo originally from H. E. Ross, appearing in the May 1950 Journal. Front row, from right: Miss E. Huggett, J. H. Edwards, Dubois, A. M. Low, W. H. Gillings, A. C. Clarke, E. J. Carnell. Back row, from right: unknown, M. K. Hanson, C. Bein, F. Day, unknown, R. A. Smith, unknown, J. G. Strong, Allen, C. G. Smith, unknown.



The famous picture of July 1938 at the home of Ralph Smith taken during visit of Robert Truax (here with rocket). Others, from left, are: Harry Ross, John Edwards, H. E. Turner, Ralph Smith, Maurice Hanson and Arthur C. Clarke.

the previous year, but Cleator's treatment was much more substantial and important [19]. Earlier, in 1931, David Lasser of the AIS wrote *The Conquest of Space*. An American edition of Cleator's book (by Simon & Shuster) also came out in 1936 and the book was widely reviewed – as far away as Argentina (a review appears in *Aeronautica Argentina* for October 1936). A copy of the book was also sent to American author and critic Henry L. Mencken as Mencken's views on religion and the social sciences coincided with those of Cleator. The result was the start of correspondence that lasted until Mencken's death in 1956. By the time of Cleator's book, BIS news began to be featured in Ralph Stranger's *Science Review* and *World Radio* as Stranger was the Secretary of the World-Wide Radio Research League (WRRL). He was rewarded with an Honorary BIS Fellowship.

End of the Liverpool Era

By the spring of 1936 Cleator had relinquished his post of BIS Council head and Bulletin editor. Pendray must have been shocked when he read of this in Cleator's letter of 8 May 1936. The letter started ordinarily enough, about forwarding on copies of *Rockets Through Space* and how "We have collected an amazing number of new members through it." Then, matter-of-factly, Cleator commented that "The only other point of any interest is that I'm no longer Editor of the Journal. In fact, I'm no longer a lot of things!" Cleator's resignation was accepted with "regret" on 24 April but, for the time being, he retained his position as President.

Unrecognised at the time, it was because of Cleator's book plus the rise in the British science fiction movement that the number of London members really began to build from this period. Although already at the BIS Annual General Meeting of 20 March 1936, Professor A. M. Low of London, who had written a foreword to the book, was "requested, and kindly consented, to become a Vice-President." There were now two BIS Vice-Presidents, Colin H. L. Askham in Liverpool and Low in London. This situation remained until the BIS move to London the following year.

Among the new London members who joined at the time and who played key roles in the move to London were J. Happian Edwards, Edward John "Ted" Carnell, and Walter H. Gillings. The latter two also became prominent in British science fiction. In his capacity as BIS Secretary (and after Cleator's resignations, editor of the Journal and Treasurer), Johnson should also be given credit for bringing these key individuals together which also did much to advance science fiction in England. "Wally" Gillings was more caught up with science fiction than space flight *per se*, but at Johnson's urging eventually agreed to permit BIS circulars to be sent to prospective subscribers to his science fiction fan magazine (or "fanzine") *Scientifiction, The British Fantasy Review* [20].

Edwards was more direct. On 22 April he wrote a letter to the BIS which was subsequently published in the Society's Journal for June, under the heading "A London Section?" Those interested in forming a London section, it was announced, should contact Edwards who had (upon the receipt of his letter) been appointed the Official BIS Representative in the Metropolitan Area.

No immediate rush was made by London members in answer to Edwards' plea, but the stage had been set. The trend towards a London move seemed irreversable,

especially considering Edwards' character. Ted Carnell painted a glowing picture of him in a letter to Johnson: ". . . He's a mathematical genius, rattles off gigantic equations, computes speeds and heats and other essentials to astronautics just like I would read a newspaper. Has the most widely varied and colourful schemes for putting the BIS right . . . the BIS couldn't be in better hands if you want it to progress . . ." Based upon this assessment, Secretary Johnson responded to Carnell in a lengthy letter of 21 August 1936, saying "I would like to see little better than that the Society should be built into something really worthwhile by the London fans. It has no real future on Merseyside . . . My idea of the situation is that we should circularise Members telling them that the Society is being transferred to London – giving the London address and seeking for the general consent of the Membership to ratify the change. I will transfer matter to yourself and Edwards gradually until the end of the year. You could then hold the Annual General Meeting in London, at which some of the Liverpool Members will try to be present." The BIS Council approved these moves and P. E. Cleator saw the handwriting on the wall. He telephoned then wrote to Johnson on 14 September, informing him of his intent to tender his resignation as President "to take place immediately after the decision is passed by the Members of the Council . . . I am quite prepared to concede that the Society may progress better if directed from London . . ."

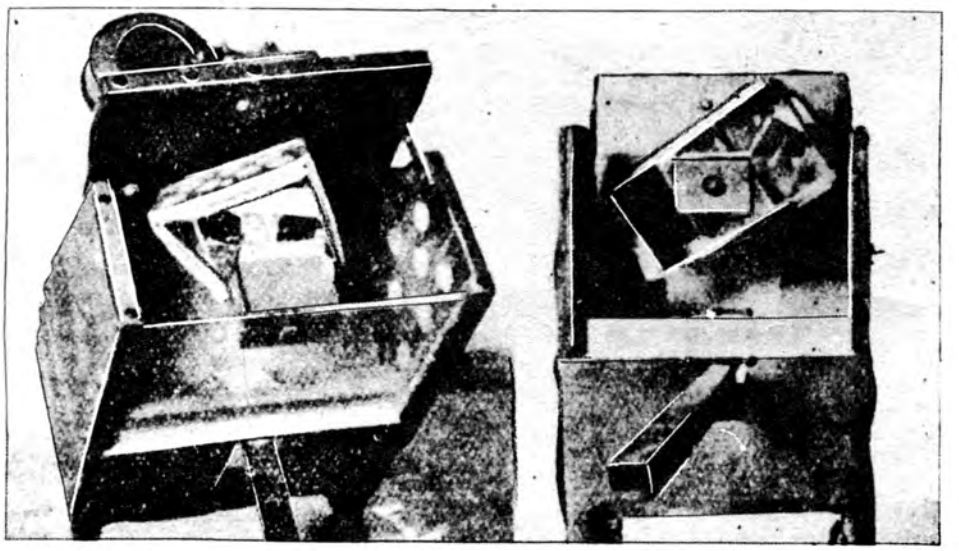
The London Era

The Council met on 18 September and, according to Johnson's letter to Cleator, it was formally decided "that it was very desirable that the London Section should be formed as soon as possible, and that should they so desire it, they should take over the management and property of the Society . . . Accordingly, it has been decided to accept your resignation as President . . ." In the meantime, Carnell, Gillings, Eric Russell, Clarke, and two newcomers, science fiction writers Maurice K. Hanson and Dennis Jacques, rallied around J. Happian Edwards to offer him support in the event the move was finally approved [21].

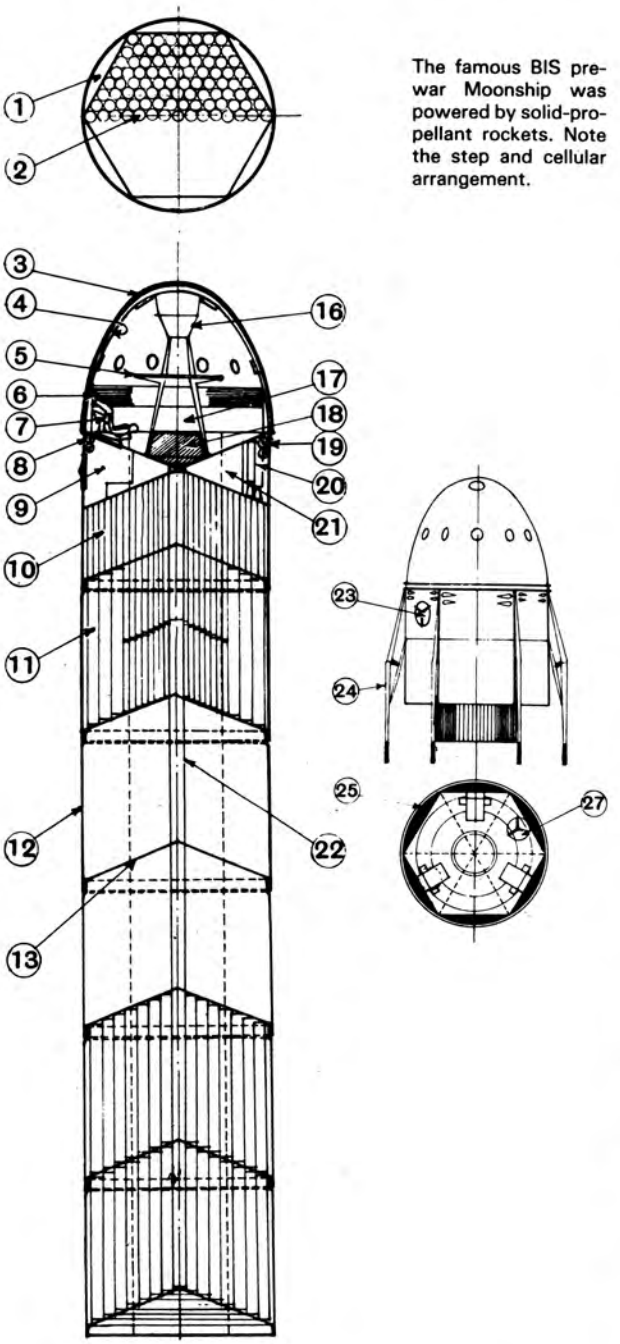
The Mason's Arms public house in Maddox St. was a pre-War BIS meeting place.

G. Phillips

The first meeting of the London Branch took place at 8.00 p.m., Tuesday, 27 October 1936 at Professor Low's offices at 8 Waterloo Place, Picadilly. The new Branch first had to justify itself before the permanent London move of the Society could be made. Nonetheless, Professor Low was nominated President of the Branch and subsequently became President of the Society. Kenneth W. Chapman and Miss Elizabeth Huggett (later Mrs. J. H. Edwards) were nominated Joint Honorary Secretaries. Clarke assumed his first BIS post, Treasurer of the London Branch. Edwards was made Director of Research and Carnell, Director of Publicity. In a subsequent meeting, held on 15 November at The Mason's Arms on Maddox Street (from then on a favourite BIS haunt, affectionately renamed The Spaceshippers Arms), a committee was



The Coelostat, for making sightings from a rotating spacecraft, was designed for the BIS lunar spaceship of 1937–1939 by J. Haffian Edwards. Ralph Smith built the model; it was demonstrated at a meeting in the Science Museum on 7 March 1939.



The famous BIS pre-war Moonship was powered by solid-propellant rockets. Note the step and cellular arrangement.

set up to draft a new constitution [22]. This committee consisted of Edwards, Carnell, Clarke, Chapman, Gillings, Huggett, and a new and later very prominent member so well known for his drawings, Ralph Andrew Smith. One noteworthy change in this constitution was the elimination of the well-meaning but almost random dispensation of Honourary BIS Fellowships.

The most important meeting at the Mason's Arms was the BIS Annual General Meeting at 7 p.m. Sunday, 7 February 1937. As anticipated by everybody, the two outstanding matters were smoothly adopted: the official transfer of BIS headquarters to London and the new Constitution. A following meeting, at Edwards' home, saw the election of Low as new BIS President and L. J. Johnson as Vice-President. Later, out of sincere respect for having fathered the BIS, Cleator was also named a Vice-President. Gillings and Carnell were made Joint Publicity Directors. Smith and Huggett were Joint Secretaries. Clarke stayed on as Treasurer. Arthur Janser was named Librarian and J. Happian Edwards, Research Director. The new, but not permanent BIS headquarters, was now shifted to 92, Larkswood Road, South Chingford, London E.4 [23].

Start of the London Era

The perennial shortage of money plagued the Londoners as it had the Liverpudlians. The first issue of the London-edited Journal did not appear until December 1937. In the interim, periodic *Bulletins* were issued, an abortive BIS jet-propelled model aircraft competition was opened (attracting no competitors!), and scores of combined science fiction-BIS meetings were held. (The late 1930's was the great British science fiction boom with much BIS business conducted in the flats and other meeting places of the up-and-coming authors and editors, notably Clarke, Gillings, Maurice K. Hanson, Carnell, and William F. Temple.) Like *Scoops* in 1934, the science fiction magazine *Tomorrow* also ran BIS and other rocket society news during this period. Appropriately, the page was called "Rocketry News."

But, by far, the greatest BIS achievement in the immediate pre-War years was the famous BIS lunar spaceship. The details, including the actual construction of a spaceship part (the Coelostat, a clever optical device for making stationary sightings from a rotating spacecraft) are well covered in all the BIS Journals from December 1937 to July 1939 as well as in the *Bulletins; Flight* for 12 February 1942; *Spaceflight* for February 1969 and March 1974; and the Smithsonian Institution's *Annals of Flight* No. 10, and elsewhere. It is therefore unnecessary to enter into this story except to say that the still-thriving Research Fund paid for the Coelostat and that work went on also with the construction of an altimeter, speedometer, primary battery, and modest propellant tests. A static proving stand was also designed early in 1939 by Ralph A. Smith [24].

Almost as well known as the lunar ship was the visit of American rocket experimenter (then a midshipman) Robert C. Truax in July 1938. Truax advocated a BIS sounding rocket but the members were literally Moonstruck. Almost obscured was the visit two years earlier by another American rocketeer, James H. Wyld (with his friend Curt Kris Baum) to P. E. Cleator; Wyld, then on the Experimental Committee of the American Rocket Society, became heralded for his regeneratively-cooled rocket engine which idea he discussed with Cleator, but probably quite unbeknownst to the rest of the BIS.

The War Years

The final order of business of the "old" BIS when the war broke out was the Extraordinary General Meeting of 10 October 1939 at 88 Grays Inn Road, Arthur C. Clarke's residence. The war rendered it "impossible for the BIS to continue," reads Clarke's circular issued to

the membership. "Consequently we have no alternative but to suspend our activities . . . We have, however, no intention of abandoning our work . . ." Those who wished to communicate on BIS business or upon any astronautical matter could write to Ballifants, Bishops Lydeard, Taunton, Somerset, Clarke's family home.

Thus, while many of the Society's leading members (including Clarke) answered the call to arms, the astronautical movement in Britain, sparked by the BIS, remained very much alive.

A previous article in *Spaceflight* details the rise and growth of other pre-war British astronautical groups, an example of which was the efforts of Norman R. Nicoll and G. R. Richardson, BIS members of Birmingham, who assembled their own Birmingham chapter in 1938. They held lectures and even fired small solid-fuel rockets (illegally!) and made castings for a projected liquid-fuel rocket until the war began [25]. Almost all these kinds of organisations likewise disbanded along with the BIS by 1939, but the Manchester Astronautical Association (MAA) under Eric Burgess and Trevor Cusack (formed in 1937) continued into the war. Kenneth W. Gatland and Harold N. Pantlin's Astronautical Development Society (ADS) was founded at Surbiton, Surrey in 1941, and in early 1944 amalgamated with the MAA to form the Combined British Astronautical Societies (CBAS). Burgess was Chairman and Gatland, Secretary. It was this group that became the nucleus of the reborn BIS. The Manchester group was named the CBAS Northern Headquarters, the ADS the Southern Headquarters, with a Midlands (Birmingham) section and Eccles, Farnborough, and London branches added later. By February 1945, the combined membership was about 300.

In the meantime, interplanetary ideas were discussed in the CBAS organ *Spacewards*, in CBAS public lectures (some given by Professor Low and other former BIS stalwarts), and in aeronautical magazines like *Flight*. Indeed, the correspondence column in the latter prestigious periodical was a powerful forum for Britain's wartime astronautical community. A lively debate, for instance, was carried out in 1941 issues of *Flight* over famed British aerodynamicist Dr. Frederick W. Lanchester's article "Rocket Propulsion" (*Flight*, **40**, 7 Aug 1941:78–80) [26]. Amongst the letter writers are familiar BIS names: Clarke, R. A. Smith, Arthur V. Cleaver, Richard Cox Abel, as well as Gatland and Burgess.

By 1944 Cleator, Clarke and R. A. Smith were openly discussing the possibility of a post-war BIS. Arthur C. Clarke was a particularly vigorous crusader for this cause. RAF Flight Lieutenant Clarke, speaking at a CBAS technical meeting at Islington, London on 20 January 1945, said he "would like to see a single, national organisation which would be recognised by everyone as *the* authority on astronautics" otherwise the public would be confused by a number of societies. This and other animated discussions led to an informal gathering at Professor Low's instigation on 13 June at the Royal Automobile Club, Pall Mall, London, specifically to deal with the re-formation of the BIS. Low presided and an emergency (i.e. wartime) BIS committee was raised from amongst those present. The members were: Low, Cleator, Mrs. J. Temple, R. A. Smith, Harry E. Ross, Gillings, Charles Bein, Leonard J. Carter, Leslie R. Shepherd, and Ralph C. G. Slazenger. Carter consequently found himself interim Honorary Secretary [27].

The BIS Council in 1957 at the 2nd International Astronautical Congress, held in London. Front, from left: K. W. Gatland, W. H. Gillings, A. C. Clarke, L. J. Carter, H. E. Ross; back: A. V. Cleaver, R. A. Smith, L. R. Shepherd, Ed. Sawyer (representing various US societies), J. Humphries, A. E. Slater, G. V. Thompson, E. Burgess.

On Saturday, 29 September 1945 a General Meeting of the CBAS was held at Birkbeck College, Fetter Lane, London, in which the respective Central Councils of the CBAS and interim BIS ratified the motion of incorporation of a national society to be named The British Interplanetary Society, Ltd [28]. This incorporation was granted 31 December 1945. Eric Burgess was elected Chairman of the new Council while Carter remained Secretary, as he has, faithfully, until this day almost 40 years later! The institution of presidency of the BIS was not adopted for the time being. Instead, Council Chairmen were elected. By the first Annual General Meeting in 1946 there were 269 members. Headquarters was at 1, Albermarle Street, Picadilly.

Post-War Goals

The years 1945 to 1983 constitute the most dynamic and creative phase of the BIS. Its complete history could fill several volumes. For brevity's sake we can only offer the barest highlights [29].

On the eve of the re-establishment of the BIS, Arthur C. Clarke recognised the reality of the German V-2 rocket *vis-á-vis* the rocket and space travel societies. In his article "The Ideal Astronautical Society" in *Spacewards* for January 1945 he wrote: "No society will ever build a spaceship. It cost the Nazis millions of man-hours and hundreds of millions of pounds to build the first rockets which reached space. All any society can do is to correlate work in fields related to astronautics, to promote interest in and discussion of the subject, to act as a clearing house for knowledge and a meeting place for those interested in the art . . . No further work along the main lines of development can be done except by large commercial or governmental organisations." Clarke's conviction about these points was so strong that they were submitted as part of the proposed aims of the BIS which were discussed and consequently approved as official BIS policy in a BIS Fellows meeting of 14 April 1946. From that time until the present the BIS has accomplished the overall aims and a great deal more, of enlightenment in the field of astronautics.

Already in the first post-war *Journal*, dated June

THE BRITISH INTERPLANETARY SOCIETY

Space Medicine Symposium

at

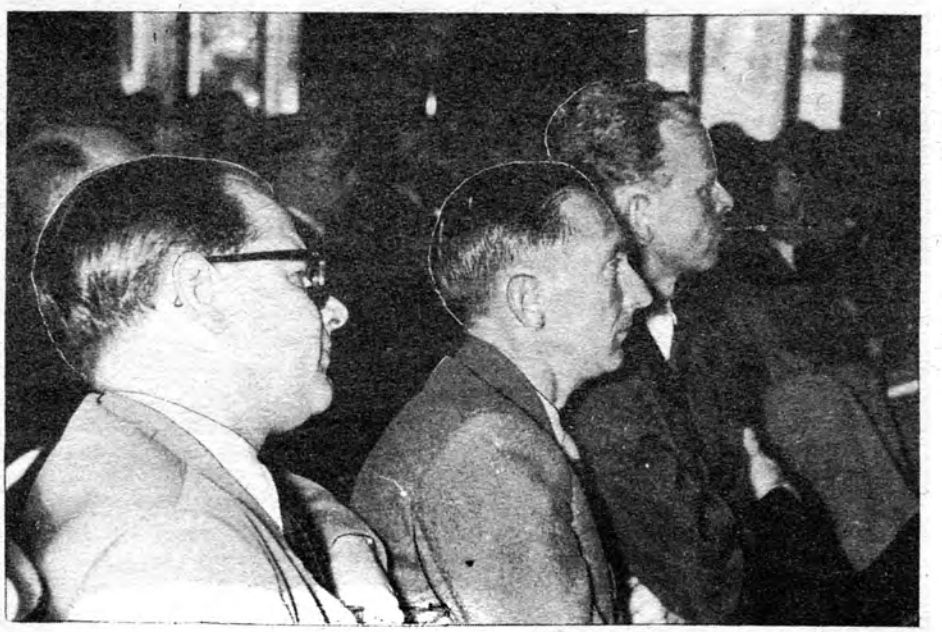
The Great Hall, B.M.A. House,
Tavistock Square, London, W.C.1
16—17 October, 1958

and

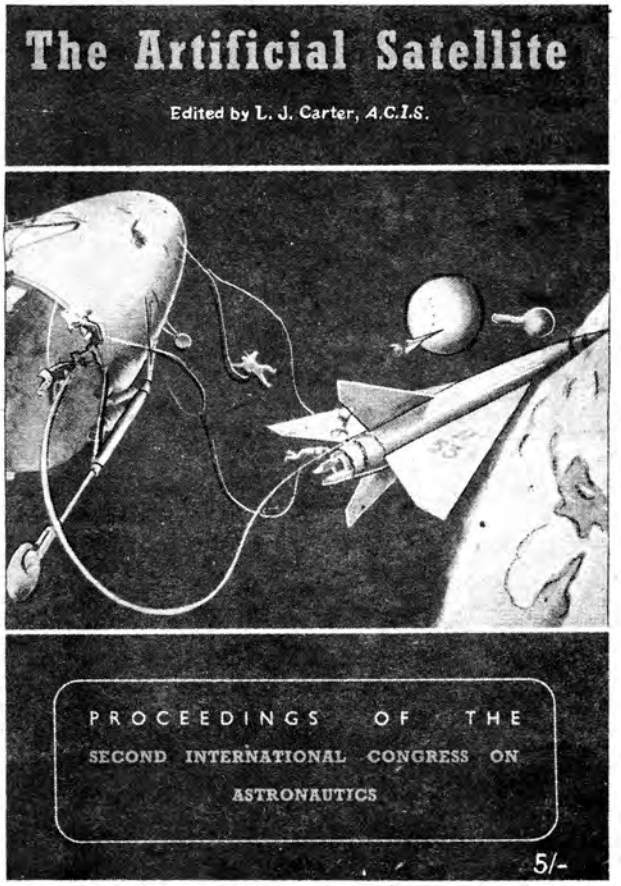
Twenty-fifth Anniversary Dinner

at

The Waldorf Hotel, London, W.C.2
17 October, 1958



Three distinguished members of the BIS listen intently to a presentation at the 3rd IAF Congress in Stuttgart, 1952. From left: A. V. Cleaver, Les Shepherd and Fred Durant.



1946, there is, besides a necrology of Robert H. Goddard, "A Survey of Atomic Power," "Sounding Rocket Radio Sonde" by member Alan E. Crawford, and "A Survey of Lunar Surface Conditions" [30]. The articles tended to be more technical and original than in the pre-war Journal although of course they reflected – literally – the explosion of the state-of-the-art. Arthur V. Cleaver's "Interplanetary Flight: Is the Rocket the Only Answer?" appearing in the June, 1947 Journal began to characterise the BIS as an *innovative* as well as informative body. In effect, the Society's non-involvement with contemporary rocket engineering freed them to take on the more visionary aspects of space flight. Thus appeared, in the late 1940's and 50's, such pioneering papers as H. E. Ross' "Lunar Spacesuit" (with equally pioneering space artwork by R. A. Smith); "Planetary Photography in the Ultra-Violet and Infra-Red" by John C. Tanner; Leslie R. Shepherd and A. V. Cleaver's "The Atomic Rocket"; R. A. Smith's "The Man-Carrying Rocket" (based on the V-2, which idea was unsuccessfully submitted to the Ministry of Supply on 23 December 1946, fifteen years before the first single-astronaut Project Mercury rocket was launched); Dr. Olaf Stapledon's "Interplanetary Man," a landmark astronautical-philosophical contribution; H. E. Ross' Orbital Bases"; A. C. Clarke's "Electromagnetic Launching as a Major Contribution to Space-Flight"; Kenneth W. Gatland's "Orbital Rockets" (shades of the Shuttle!); L. R. Shepherd's "The Artificial Satellite"; "Psychological Problems of Spaceflight" by Dr. E. T. O. Slater, MD; E. R. Nye's "The Possibility of Potentially Pathogenic Organisms Occurring on Another Planet"; L. R. Shepherd's "Interstellar Flight" (appearing in 1952); and many others.

Some of these papers were presented as lectures advertised both in the *Journal* and in the respected magazine *Flight* which has always continued to support the Society as a respectable member of the aeronautical and now astronautical communities [31]. The Society also elected its first post-war Honorary Fellows from this time, but not so freely as in pre-war days. The Constitution, further revised in 1965, came to limit the number to 15. Professor Hermann Oberth became the first, on 12 February 1949. He was followed by Guido von Pirquet, Robert Esnault-Pelterie, Eugen Sänger and other early astronautical greats. In 1949 the Society also began to hold its meetings in the spacious Caxton Hall in Westminster.

Undoubtedly one of the greatest BIS milestones in this period was the Society's participation in the First International Astronautical Congress, held in the Richelieu Grand Ampitheatre, Sorbonne, Paris, from 30 September to 2 October 1950 in which eight countries were represented (Argentina, Austria, Denmark, France, West Germany, Great Britain, Spain, and Sweden). Cleaver, Shepherd, Clarke, Burgess and John Humphries were the BIS delegates. Through their efforts, the annual IAF Congress has become a premier astronautical event with very important papers presented. The Second Congress was convened in London at Caxton Hall.

The mid-to-late 1950's was far from a fallow time in the world of astronautics. In addition to the Journal, a new BIS publication, *Spaceflight*, appeared in 1956 and instantly proved immensely popular as it has up til now. The Journal became more technical while *Spaceflight* covered the whole gamut of astronautics. The following year saw the start of the International Geophysical Year (IGY) with its multitude of sounding rockets (including Britain's Skylark) and emphasis on solar studies. The IGY reached a grand climax with the launch of the world's first satellite, Sputnik 1, on 4 October 1957.

Into the Space Age

By year one of the Space Age, 1957, BIS membership had climbed to more than 3,000 and the Society had already established a solid reputation in its field. That year also saw the BIS take part in a symposium and exhibition on High Altitude and Satellite Rockets at the College of Aeronautics, Cranfield, in which specialists from nine countries participated [32]. The following year, in conjunction with the Society's 25th anniversary, the BIS co-sponsored the first British Symposium on Space Medicine with the Royal Air Force. The 10th IAF Congress in 1959 in which the Society played a leading role, was held in London. But alas, despite the Society's plea for Britain's own space programme, utilising the Black Knight and Blue Streak rockets at the Woomera range in Australia, the Government cancelled the vehicle out of financial constraints.

The cause of space flight has been brilliantly served nonetheless. Since 1961 the BIS has sponsored the European Space Symposia, exerting no small influence

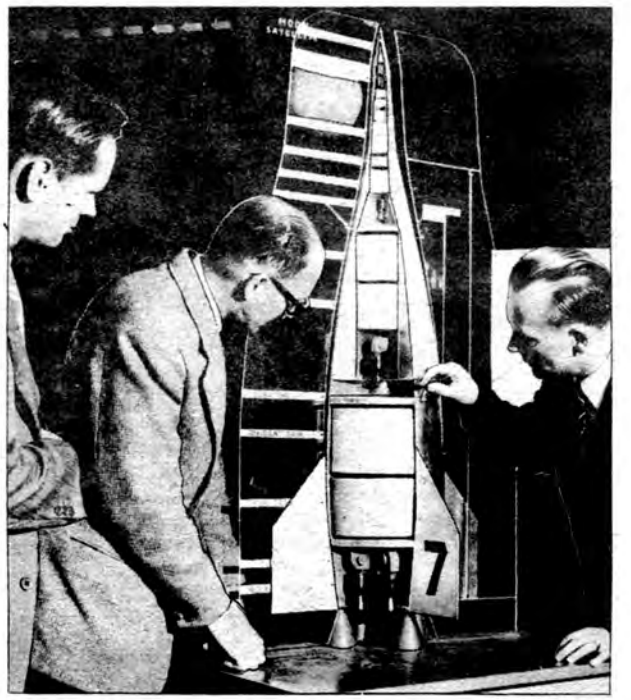
upon collective European space policies and programmes. During 2-11 May 1962 the Society also sponsored an international exhibition at Olympia, London, devoted to technological utilisation of space by bringing together manufacturers from both Britain and other nations. The Society was also instrumental in helping to establish the European Launch Development Organisation (ELDO) which afterwards became the European Space Agency (ESA). The BIS' educational role was also accelerated from this period, with special BIS sponsored courses taught at the College of Advanced Technology, Birmingham, and the publication of *The Teacher's Handbook of Astronautics* and later texts.

The 1970's represented a greater time of challenge. The Space Age mushroomed into new and complex disciplines requiring ever more advanced educational programmes to "serve industry, research institutions, government establishments and the general community through the interchange and dissemination [of ideas] . . ." The BIS particularly concerned itself with space technology utilisation. It was thus in 1975 that a BIS £25,000 Development Fund was initiated. The main thrust of this ambitious programme was to further internationalise BIS activities. The programme translated into expanded participation in international symposias and producing a greater flow of needed technical reports, upgraded texts for graduate and post-graduate studies, wallcharts, books and booklets, an enlarged film rental service for the benefit of educational institutions, and the continuation of the BIS-NASA Spacemobile – a van that took professional space lecturers and displays directly to schools, colleges, and universities.

It was also during this heightened period that the BIS Southern California Branch was organised in the Los Angeles area, the centre of the American aerospace industry. The first branch meeting was held in 1975. Long-time BIS member and former Chairman Eric Burgess was the invited speaker.

One of the most recent developments has been the move from headquarters at 12, Bessborough Gardens, to new quarters at 27/29 South Lambeth Road. This move was prompted by a massive re-development of the area in which all existing buildings were ordered demolished [33]. As *Spaceflight* readers know, the digging at the Lambeth site has not been without its own history. Progress of the move was regularly reported, as were the unearthing of 19th century clay pipes and other relics of a pre-project Daedalus starship age [34].

And finally this brings us to Daedalus, a fantastic nuclear-pulse, unmanned spacecraft designed between 1973 and 1977 by a team of 13 BIS engineers (including "old-timer" James G. Strong) from current and forecasted data extrapolated to the 21st century [35]. The 54,000 ton ship is conceived to make a 50-year exploratory voyage to Barnard's Star, almost six light years from Earth. Daedalus is a far cry from the 1937–1939 BIS Lunar Spaceship, upon which Strong also worked, both in projected mission and technology. But the two projects are otherwise identical in epitomising the broad BIS philosophy throughout its history: to be always visionary, to seek out the most comprehensive engineering solutions to those visions in a cooperative venture, and to be always loyal to the ideal of space flight as the destiny of man.



K. W. Gatland (right) explains his model of a satellite launcher at the 1955 Radio Show, Earl's Court, London.

Andrew G. Halley collection, National Air & Space Museum, Washington, D.C.

NOTES & REFERENCES

1. See *JBIS "Astronautics History"*, 35 (December 1982): 530–540. Goddard published his work in 1919 but it was released by the Smithsonian in January 1920.
2. The author has written a detailed study of these and other early rocket groups, titled *Prelude to the Space Age: the Rocket Societies 1924–1940* published by the Smithsonian Institution Press, Washington, D.C., 1983.
3. Genn was also a writer of children's stories. In the same year (1929) he wrote "Let's Pretend".
4. The unmmistakable role of science fiction throughout the life of the BIS is dealt with in the article "Just Good Friends?" by Alan Farmer, in *Spaceflight*, 17, (Nov. 1975): 395–402.
5. On 16 August 1931 J. Mansell of Birmingham wrote to the AIS expressing a keen interest in the subject, adding that there then existed a group in England which "closely follows all developments in science and interplanetary travel research especially." This was Gillings' Ilford Circle. "Unfortunately, Mansell lamented, "it is the only one in the country at present."
6. The magazines were so-called "pulps" because of the cheap grade of paper upon which they were printed. Cleator was interested in rockets since boyhood. When 14, he invented a rocket pistol which he attempted to manufacture for his school chums at 6d each. "Alas!" he later wrote, ". . . the whole school had guns all right—they made their own."
7. The word "astronautics" was coined in 1928 by French writer J. H. Rosny, Sr.

FIFTY YEARS ON

The movement originated with an appeal for members which I published in a city newspaper (the Liverpool *Echo*) on 8 September 1933. If I remember aright, there were five of us at the inaugural gathering held on the 13th of the following month, at which we solemnly pledged ourselves to begin the task of making the inhabitants of the British Isles rocket conscious and interplanetary minded – on the face of it, a lunatic undertaking which, in the astronautical Dark Ages of the 1930's, inevitably encountered difficulties and discouragements of a monumental order.

Although at birth the organisation was everywhere reviled and dismissed by the sober minded as premature and misbegotten, it nevertheless managed to survive, and in the days ahead, gradually to flourish. This invigoration was in large measure occasioned by the transfer of management from the provinces to London, an event which took place in 1937. Thereafter, with the wartime development of the German V-2 rocket, the possibility of achieving the conquest of space suddenly gained a credibility among the gentlemen of the scientific hierarchy which it had hitherto been studiously denied. Membership of the Society benefitted accordingly, as witness the world wide influence and prestige which it now exerts and enjoys.

As one who for several decades has observed the transformation from amateur to professional status ensconced on the sidelines, it becomes my privilege and pleasure to congratulate the Society on the high esteem in which it is now universally held, and to commend all those whose combined efforts have served to bring this about. And as the BIS enters the 51st year of its existence, I shall be excused, I hope, if I express mild astonishment, not only that the year 1983 finds it very much in being, but also that I myself am still around to applaud the fact.

P. E. CLEATOR
First BIS President

8. Conrad lived to see Moonflight. He retired a full professor from the Academy in 1955 and died in 1974 aged 84.
9. An earlier detonation "all but blew off" his hands.
10. The surviving Minutes of the BIS show that Miss Heaton resigned in the meeting of 6 July 1934.
11. Cleator made at least three trips to Germany that year but apparently only one which included BIS-VFR business
12. The gratuitous dispensation of these early Fellowships had another effect: it makes for some confusion as to how many and who were the actual founders of the Society (i.e. present at the inaugural meeting).
13. Charles Bein's interest in Zucker's activities was due to his being also called "an important collector of rocket mail." Bein remained a BIS member until his death in 1956.
14. This was apparently the first time that Pendray wrote to Cleator, although the BIS had already received communication from AIS officers C. P. Mason and Laurence Manning, the latter the Canadian-born AIS President in 1934 and also a noted science fiction writer.
15. Pendray was not the first American "member" of the BIS. By May 1934, a Mr. S. Tucker of Far Rockaway, Long Island, New York, was apparantly the first bona-fide, dues-paying US member.
16. For his visit, Ley actually stayed in the home of one of Cleator's friends.
17. The author is grateful to the late Leslie Johnson for information on *The New Columbus*. He says the *Columbus* duplication process was not complete. The last pages are thus blank.
18. The law was either forgotten or disregarded by the British postal authorities in letting Gerhard Zucker perform his experiments; the author has seen a copy of permission given to him by the Post Department. Grindell-Mathews was perhaps working under a Government contract in carrying out his work, as it was certainly well known.
19. Philp's book is reviewed in *Popular Flying*, **4** (June 1935):160.
20. In 1937 Gillings produced the more well-known *Tales of Wonder*, Britain's first, true, non-tabloid science fiction magazine.
21. Gillings was so busy promoting science fiction that he actually did not join the BIS until late November 1936, though he had already been active in BIS affairs!
22. This was not the second BIS Constitution but the third; a second had been tried upon Cleator's resignation from the Council in Liverpool.
23. The South Chingford address, one of several BIS headquarters over the years, was the home of member Harry E. Ross, mentioned below.
24. It should also be added that Coelostat was on exhibit in the Science Museum on 7 March 1939. An attempt has been made to locate the whereabouts and subsequent history of the Coelostat by the author but without success. Any leads will be gratefully appreciated.
25. See "Astronautics in Britain" - 3-1936-1948," in *Spaceflight* **9** (July 1967):234-236. The Birmingham group's rocketry activities are not mentioned, nor is the fact that Nicholl helped R. A. Smith on the 1939 BIS lunar spaceship, concentrating on the life-support system.
26. See also, *Flight*, **40**: 124, 239, 305, 346, 384,, 430 and **41**: 260, 295, 328 and 354.
27. Shepherd, who has remained a prominent member until the present, was also one of the first. He joined in 1934.
28. The date of 25 September cited by the aforementioned *Spaceflight* article appears to be incorrect. September 25th was the date of the inaugural meeting of the London Branch of the CBAS, also held at Birkbeck College, according to the September 1945 CBAS Bulletin.
29. Even before the BIS was re-constituted, Arthur C. Clarke, in the name of the BIS, made a suggestion in *Wireless World* for February 1945 (p. 58) that V-2 rockets be used for upper atmospheric (ionospheric) research and as a launch vehicle for communication satellites. This seems to have been the first suggestion ever of communication satellites. Clark subsequently circularised his idea to BIS (interim) officials on 25 May 1945, then had his now classic paper "The Space-Station Its Radio Applications" published in the October 1945 issue of *Wireless World*.
30. Goddard died in Baltimore on 10 August 1945. Member Crawford is alleged to have built a liquid-fuel rocket

during the late 1930's surreptitiously, according to Eric Burgess.

31. For a notice of Olaf Stapledon's talk before the BIS at St. Martin's School, London, 9 October 1948, see *Flight, 54* (21 Oct. 1948): 498.
32. See *Flight*, **72** (2 Aug. 1957: 153–156.
33. See, for example, "The Society Will Need To Move," *Spaceflight*, **16** (March 1974): 117–118.
34. For coverage on the history of the Lambeth site, see Eric Waine's "Space Centre in Vauxhall." *Spaceflight*, **21** (Oct. 1979): 409–412; and *Spaceflight*, **24** (Nov. 1982): 431 and **25** (Jan. 1983): 44 for other examples.
35. Unfortunately, James G. Strong missed the BIS 50th anniversary by one year. He died in 1982.

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MILESTONES

August 1983

1 NASA announces that STS-8 will be launched on 30 August. STS-9, with Spacelab 1 aboard, is now scheduled for 28 October, instead of 30 September, to give engineers more time to bring the TDRS-1 communications satellite into use for the scientific mission. Spacelab is inserted into the Shuttle on the 18th.

1 It is reported that Space Services Inc. of Houston plans to launch its first commercial Conestoga 2 satellite vehicle in mid-1985.

1 ESA and Arianespace sign the contract to provide for the launch of the Marecs-B2 communications satellite by Ariane next year.

2 The Space Shuttle is moved to the launch pad for the STS-8 launch on 30 August.

9 A two day simulation of the STS-9/Spacelab 1 mission is completed. The flight crew controlled a Shuttle simulation at Johnson Space Center, while the science crew operated a Spacelab mockup at the Marshall Space Flight Center.

11 It is announced that the IRAS observatory has discovered a shell or ring of material about Vega, 26 l.y. away. The debris was probably left over from the star's formation; a planetary system is a possibility.

11 NASA's Ames Research Center in California announces that the Galileo Jupiter probe, dropped from a balloon 30 km up on 25 July, operated successfully.

14 Cosmos 1443 undocks from Salyut 7/Soyuz T-9. A re-entry vehicle returns on 23rd. Progress A is launched on the 17th to deliver fresh supplies.

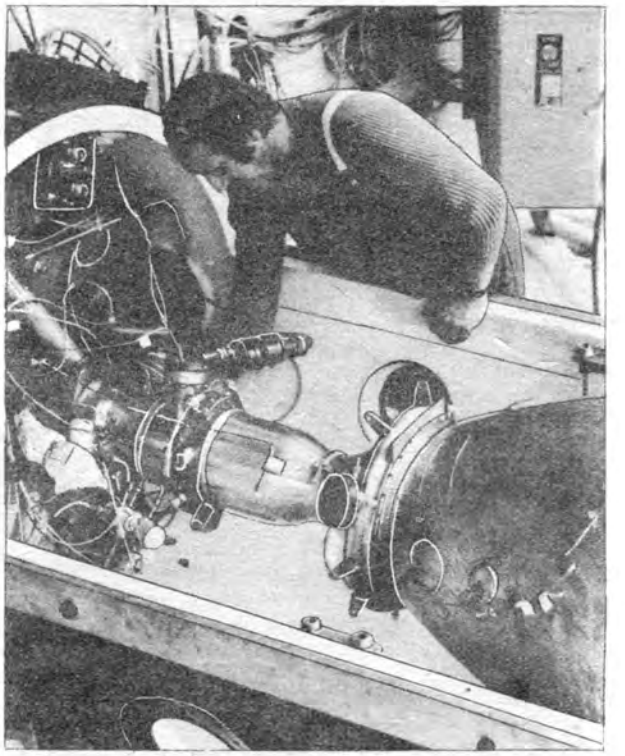
15 It is reported that the Soyuz T-8 docking with Salyut 7 failed in April because the Soyuz rendevous radar did not deploy from its launch position. Commander Titov attempted a visual approach but abandoned it when he decided the risk was too great.

22 Shuttle Orbiter *Columbia* will be grounded until November 1985 after the STS-9 mission in the autumn, it is reported. The facilities at Rockwell's plant in California are under pressure from B-1 bomber work and *Columbia's* modification to a fully-operational craft will have to be delayed. It will also be used as a source of spare parts for *Challenger* and *Discovery*. Other changes: STS-12 will now fly in May 1984 *after* STS-13 because of the Interial Upper Stage problems; STS-13 is now scheduled for 4 April 1984. STS-10 has still not been rescheduled. The Space Telescope launch is now set for 13 August 1986.

30 The STS-8 Shuttle mission is launched at 06.32 GMT, with astronauts Truly, Brandenstein, Gardner, Bluford and Thornton. The Indian Insat 1B satellite is released on the 31st and *Challenger* makes a night landing at 04.40 GMT in California on 6 Sept.

DO YOU KNOW?

A technician inspects a rocket motor before it undergoes testing. A failure during the firing of this stage in September 1982 led to two satellites being lost, one of them for maritime communications. What is it?



Answer: this is the HM-7 motor of Ariane's third stage. Ariane L05 plunged into the Atlantic with the Marecs-B and Sirio satellites aboard.

DO YOU REMEMBER?

25 Years Ago . . .
5 November 1958. The Space Task Group comes into being at Langley Field to begin the Mercury project.

20 Years Ago . . .
18 October 1963. NASA announce the selection of 14 new astronauts to form the third group.

15 Years Ago . . .
26 October 1968. Cosmonaut Beregevoi is launched in Soyuz 3 to rendezvous with Soyuz 2. It is the first manned Soviet flight in 18 months.

10 Years Ago . . .
3 November 1973. The Mariner 10 Venus-Mercury probe is launched. It flies past Venus in February 1974 and makes three passes of Mercury in 1974 and 1975.

5 Years Ago . . .
13 November 1978. The HEAO 2 X-ray astronomical satellite is launched.

D.J. SHAYLER

EXAMINE ON APPROVAL FOR 30 DAYS

A complete chronological list of the 2,389 launches of satellites and space vehicles between 1957 and the end of 1982, including satellites about which no other data is available

- Name and international designation of each satellite and its associated rocket(s)
- Date of launch; lifetime (actual or estimated)
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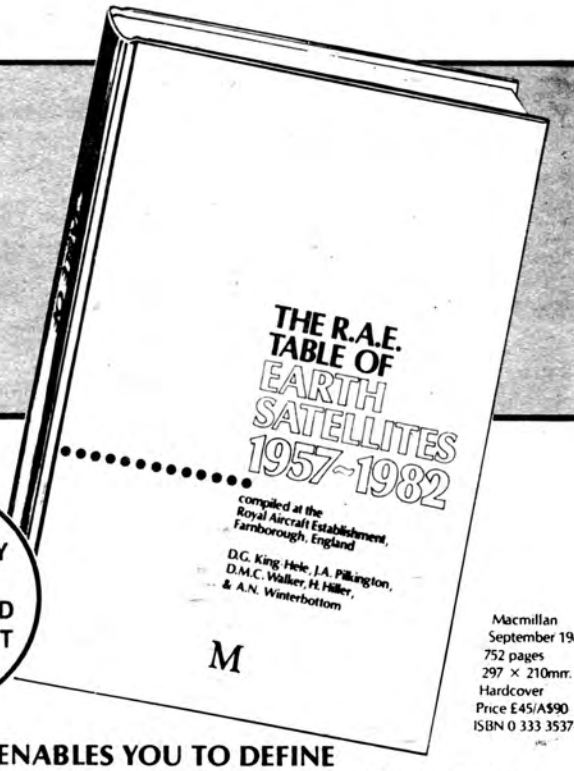
THE R.A.E. TABLE OF EARTH SATELLITES 1957-1982
compiled at the Royal Aircraft Establishment, Farnborough, England
D.G. King-Hele, J.A. Pilkington, D.M.C. Walker, H. Hiller, & A.N. Winterbottom
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Year of launch 1982 continued

Name		Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Date of orbital determination	Orbital inclination (deg)	Nodal period (min)	Semi major axis (km)	Perigee height (km)	Apogee height (km)	Orbital eccentricity	Argument of perigee (deg)
Cosmos 1382 launcher	1982-64C	1982 Jun 25.10 20 days 1982 Jul 15	Irregular	-	1982 Jun 25.5	62.83	92.44	6774	185	606	0.031	119
Cosmos 1382 rocket	1982-64D	1982 Jun 25.10 100 years?	Cylinder 440	2.0 long 2.0 dia	1982 Jun 28.1	62.78	708.50	26326	603	39293	0.735	316
TS 4* Columbia F4)	1982-65A	1982 Jun 27.62 7.1 days 1982 Jul 4.7	Cylinder + delta wing 68800 empty	37.1 long 17.4 high 23.8 span	1982 Jun 28.6	28.52	90.33	6677	295	302		
smos 1383	1982-66A	1982 Jun 29.91	Cylinder									

Inclination of orbit to equator · Time taken to go round Earth · Average radius of satellite's orbit · Point of orbit closest to Earth · Point of orbit furtherest from Earth · Defines shape of orbit · Defining position of perigee relative to equatorial plane

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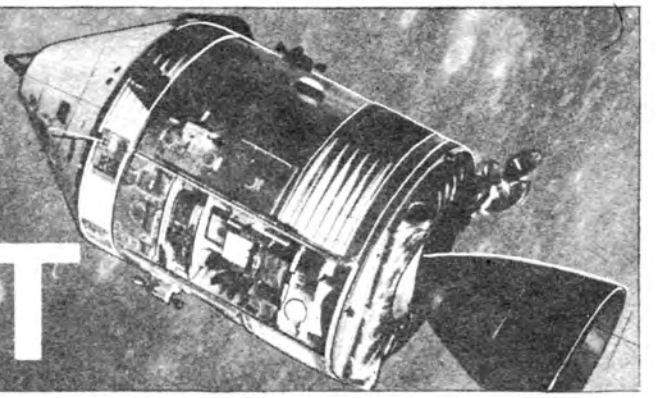


THE WAY AHEAD

The five STS-7 astronauts appeared before a US Senate Committee on Commerce, Science and Transportation in July to present their views on the development of space technology. Commander Bob Crippen – he will make his third Shuttle trip with STS-13 next year – said that a permanent US space station should be established "at the earliest possible moment". He added, "We need that station not only for a continuous presence in space but also to return to the Moon. We will also go to Mars but we need a space station to get there."

The space agency is also studying the possibility of allowing non-astronauts to fly aboard the Shuttle. Crippen said, "A NASA committee is looking specifically at people like journalists, poets, musicians and the like for future flight. I would expect that something of that nature will occur in the next couple of years."

NASA Administrator James Beggs said that NASA would not be averse to flying another manned mission with the USSR: "We should need the assurance of Soviets that they would be willing to open their programme a little more. We would like to do it again."

LANDSAT 4 FAILURE

The Landsat 4 Earth resources satellite is continuing to produce excellent Multispectral Scanner (MSS) Earth imagery although the recent failure of two cables routing power from the solar panels to the batteries is causing concern.

The satellite can operate its MSS on 50 per cent power but there are signs that the remaining two solar panels could lose their cables through identical faults. Ground controllers have been careful to position the satellite so that the cables are not subjected to extreme thermal conditions.

The new Thematic Mapper instrument has been unusable since February because of the X-band transmitter failure and controllers had hoped to regain its use now that the TDRS 1 communications satellite orbited by the sixth Shuttle mission is in position. The power loss will now limit that operation.

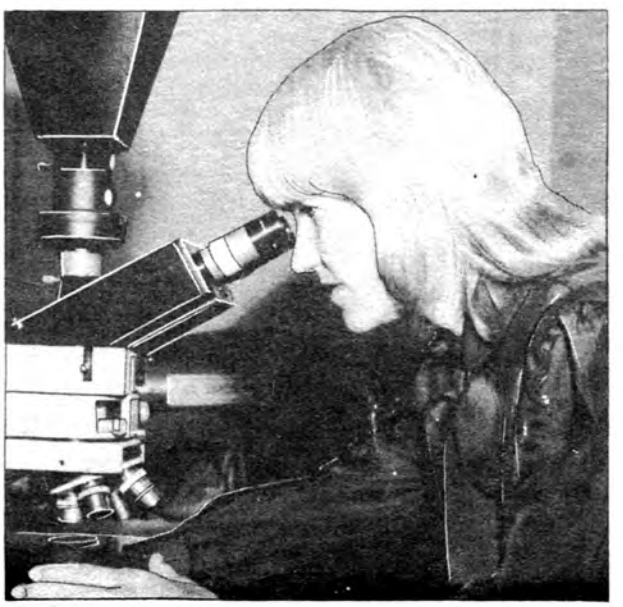
Meanwhile, the Landsat 2 and 3 satellites have been taken out of service and put into standby mode – they were due to be permanently retired at the end of September. Landsat 2 alone returned 615,720 MSS Earth images during its career.

Late News: Work is now underway to launch Landsat D-prime, the backup satellite, next February with suitable modifications to the faulty wiring. In 1985 or 1986 a Shuttle mission might rescue the troubled Landsat 4 and repair it in orbit. Astronauts Story Musgave and Jerry Ross have already visited General Electric, the satellite's builders, to look at the possibility of EVA work. Landsat would have to be brought down some 150 km from its current orbit to bring it within the Shuttle's range.

SPACELAB 3 ASTRONAUTS

Four scientists were named by NASA in early June to train as payload specialists for the September 1984 Spacelab 3 mission, the first operational flight of the laboratory. Those named are: Dr. Eugene Trinh and Dr. Taylor Wang, both of JPL, Dr. Mary Helen Johnston, of NASA's Marshall Space Flight Center, and Dr. Lodewijk van den Berg, of EG&G, Inc. Only two will actually make the flight.

"The specialists were selected by the Investigator Working Group, consisting of the principal investigators

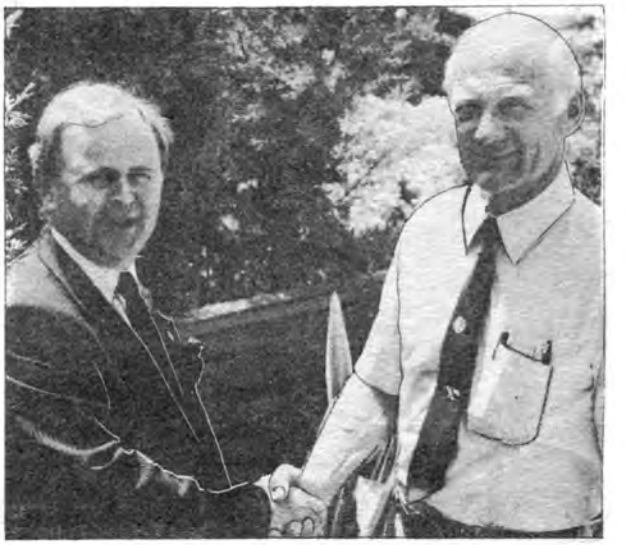


Mary Helen Johnston is a Spacelab 3 payload specialist candidate. *NASA*

(scientists) responsible for each of the experiments on the mission," explained Dr. George Fichtl, mission scientist at the Marshall Space Flight Center. As mission scientist, Fichtl also serves as chairman of the working group.

"There are two areas of research to be examined on Spacelab 3 that require the presence of crewmembers with specialized backgrounds," he said. "The investigator group selected Trinh and Wang for their expertise in liquid drop dynamics and Johnston and Van den Berg for their expertise in materials science. One payload specialist from each of these two disciplines will be selected to fly."

While the seven-day flight will emphasise materials processing, other major Spacelab 3 experiments have been selected from life sciences, Earth observations, space technology and astrophysics. Of the 13 scheduled experiments, 11 are from the US while India and France will have one each. For Mission 3 the laboratory will consist of a pressurized module, in which the scientists will work, and a special support structure to carry equipment requiring direct exposure to space.



Watson Laing (left) of British Aerospace acted as the Society's representative at the Paris Air Show this summer. He is pictured here with Apollo 11 astronaut Buzz Aldrin — who, we note, is wearing a BIS tie!

FIRST "COMMERCIAL" ASTRONAUT

As noted in the last issue's "Shuttle Launch Schedule" listing, NASA has now named Charles Walker as a payload specialist for the twelfth flight, now scheduled for May 1984. Walker is not a NASA astronaut but an engineer at McDonnell Douglas Astronautics Co. in St. Louis; he will be the first payload specialist to represent a project designed for commercial purposes.

His job will be to run the materials processing device developed by McDonnell Douglas as part of its Electrophoresis Operations in Space project. This project is aimed at separating large quantities of biological materials in space for ultimate use in new pharmaceuticals.

For STS-12 the current device which has flown three times will be reconfigured to operate continuously throughout the mission to produce sufficient material for clinical testing.

Walker joined McDonnell Douglas in 1977 and has worked on the electrophoresis project since its beginning in 1978. He is currently chief test engineer for the project with repsonsibility for space flight testing and evaluation. He has also been involved with the project support efforts at Kennedy Space Center and Mission Control, training the NASA astronauts who have operated the equipment for research on earlier Shuttle missions.

APPLE'S CORE OF SUCCESS

By mid-June 1983 India's Apple satellite had successfully completed two years in orbit, writes Gerald L. Borrowman. Launched on 19 June 1981 as an Ariane Passenger Payload Experiment – hence its name – Apple was India's first experimental geostationary communications satellite. Since then it has been used in a wide range of communications tests, including facsimile newspaper printing, emergency work during cyclone relief operations and TV broadcasting.

Ground controllers have had to contend for the entire period with one of the two solar panels staying in its stowed position, complicating thermal and power conditions. The attitude control propellant remaining on the second anniversary led planners to expect that the satellite would be operational until early this autumn.

ITALIAN SPACE PROJECT

For their initial experience with space astronomy, Italy will collaborate with the Netherlands on an X-ray satellite called SAX, writes Joel Powell. It will be the third space astronomy project for the Dutch, following on the heels of ANS and the eminently successful IRAS infrared observatory. SAX is part of an Italian research programme begun in 1979–80 which includes the Tethered Shuttle Satellite (TSS), the Italian Research Interim Stage (IRIS) solid rocket motor to be flown on the STS-34 Shuttle mission in late 1985, and an Italian telecommunications satellite. A repeat of the SIRIO-2 satellite (lost in the Ariane L5 launch failure) may also be conducted.

NEW SHUTTLE TILES

New lightweight thermal protection tiles will reduce the Space Shuttle's weight by about 900 lb and will allow the orbiter to carry more payload or additional passengers into space. Called FRCI-12 (Fibrous Refractory Composite Insulation, 12 lb per cubic foot), the new heat-resistant tiles will be used for the first time on *Discovery*, the third Orbiter.

They will cover access doors, main landing gear doors and other areas that require a stronger insulating material than LI-900 (Lockheed Insulation, 9 lb/cu ft).

Tiles weighing 22 lb/cu ft. (LI-2200) are currently used in such areas on *Columbia* and *Challenger*.

Discovery will have about 2300 FRCI-12 tiles. LI-900 tiles will continue to be the primary insulating material on the Shuttle's underside; LI-2200 will also be used in some areas.

Unlike the pure-silica tiles, FRCI is composed of 78 percent silica fibres and 22 percent Nextel fibres that contain a small amount of boron. During high-temperature sintering in a furnace, the boron welds the pure-silica and Nextel fibres into a rigid structure. The result is a lighter material with strength equal to the heavier LI-2200.

Bud Aine, Manager of Thermal Protection Systems at Lockheed, says he is impressed with the tiles' performance. Of the nearly 31,000 tiles of *Challenger*, only about six received minor nicks from pieces of ice flying from the super-cold liquid oxygen fuel tank during the STS-6 launch in April.

NASA decided to install Lockheed's low-temperature white tiles on the leading edge of *Challenger's* Orbital Maneuvering System (OMS) pod prior to the Orbiter's second flight in June. The Advanced Flexible Re-usable Surface Insulation used in this area was damaged during reentry at the end of the STS-6 mission.

LI-9000 white-coated tiles are designed to withstand temperatures ranging from 400 to 670°C. Black-coated tiles take over protection requirements in the 670 to 1300°C range.

Lockheed began investigating re-usable lightweight silica thermal protection systems in the early 1960's as an alternative to heavy ablative materials that could be used only once.

Lockheed expects to complete the tiles for *Atlantis*, the fourth Orbiter, in July 1984. When those are completed, Lockheed will have provided more than 90,000 individual tiles for the four Space Shuttles – enough to cover about an acre of land if placed side by side.

IRAS FINDS A COMET'S TAIL

The Infrared Astronomical Satellite (IRAS) has discovered a 30 million km-long tail on Comet Tempel 2 – a comet on which no tail had ever been seen before. The long, thin tail of dust was spotted in data from IRAS's ultrasensitive telescope by John Davies (a member of the Society) from the University of Leicester group which has found four new comets since April using data from the IRAS. IRAS detects the heat emitted by celestial bodies and thus has a different view of the sky than that seen either by the naked eye or with most optical telescopes.

The orbiting telescope, which is conducting a year-long all-sky survey of infrared-emitting objects, recently detected what appeared to be a large number of objects all moving together. Astronomers soon realised that the objects were connected with Tempel 2, an association that was confirmed when the comet itself was detected by IRAS a few days later. No tail or debris from this comet had ever been seen from the ground, probably because it is so faint in visible light that even the largest telescopes would require very long exposures to photograph it.

More careful analysis revealed that what they were detecting was not, as first appeared, composed of discrete objects but was in fact homogeneous and exceedingly long and narrow, its width being less than one per cent of its length. It is composed of dust that has blown off the comet's nucleus. The dust is warmed by the Sun just enough to cause it to radiate, mostly in the infrared.

Tempel 2 is one of the half dozen best known comets. Its orbit around the Sun has a relatively short period, coming inside the orbit of Mars every 5.28 years. Its nucleus is probably about 2 km in diameter. It made its closest approach to the Sun on 1 June; from early September to mid-October it was within 150 million km of the Earth, before heading back into the outer regions of the Solar System.

The discovery is important since most short period comets like Tempel 2 do not have visible tails because at each passage near the Sun some of the material is lost, and the tail gradually fades over the years. Some astronomers now suspect that all comets, even faded or quiescent ones, may have tails that could be detected in infrared light.

UK ASTRONAUT

It was announced in July that NASA has offered the UK Ministry of Defence the opportunity of flying a Payload Specialist astronaut aboard a 1985 Shuttle mission, writes Dave Shayler. The flight would deploy the Skynet 4 military communications satellite, although at the time of the announcement there was still a possibility of Europe's Ariane rocket being used.

UK newspapers claimed that a leading contender is a Royal Navy communications engineer, although both NASA and MoD denied there had been a selection. The successful candidate will not be the first British astronaut. Welsh-born John Llewellyn was chosen as a Group 6 NASA scientist-astronaut in 1967 after becoming a US citizen the previous year. He resigned in September 1968.

INTERSTELLAR STUDIES *JBIS*

The November issue of the Journal is devoted to "Interstellar Studies". Papers will include "The Search for Extraterrestrial Artifacts", "Extraterrestrial Intelligence in the Solar System", "The Case for Interstellar Probes" and "Beyond the Thousand-Year Ark: Further Study of a Non-Nuclear Interstellar Flight".

Individual copies of *JBIS* are available at £2 ($4) each, post free from: The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ, England.

The December issue will be devoted to "Astronautics History" under the editorship of Mitchell R. Sharpe.

JUST DROPPING IN

There is a great deal of research going on into reusable-upper stages these days, some of them (as we pointed out on p.60 of the February issue) using aerodynamic braking in the atmosphere to save on propellants.

This artist's impression shows an Aeroassisted Orbital Transfer Vehicle slowing down in the thin upper reaches of the atmosphere after dropping down from a higher orbit where it released a satellite. Having slotted into a new orbit it can now be picked up by a Shuttle Orbiter for reuse.

Inflatable wings on each side of the core propulsion module provide control, and a modified coating of Shuttle thermal material provides protection against the heat generated from friction with the air. Since the stage will be operating from higher orbits than the Shuttle itself, the resulting re-entry temperatures will be much greater.

It is hoped that some 18,000 to 27,000 kg of propellant can be saved using aeroassist methods. Boeing Aerospace are presently studying the pros and cons of such a system under contracts to NASA and the US Air Force.

MARECS-B2 FOR ARIANE

ESA and Arianespace, the company marketing the Ariane rocket, signed a contract in early August for the launch of ESA's Marecs-B2 communications satellite by one of the first Ariane 3s in the first half of 1984. Ariane 3, more powerful than Ariane 1, is designed to place a single satellite of the 2500 kg class, or two of the 1200 kg class, into geosynchronous transfer orbit.

Marecs-B2, with a launch mass of 1050 kg, replaces its predecessor which was lost following the failure of the Ariane L5 rocket on 10 September 1982.

The Marecs programme covers the development, launch and in-orbit operation of two satellites integrated into the Inmarsat global maritime communications system. Marecs-A was launched by Ariane L04 in December 1981 and has been operating successfully since early 1982 from its orbital position at 26°W above the Atlantic Ocean. Marecs-B2 will be stationed at 177.5°E above the Pacific Ocean.

The Marecs satellites provide shipping and off shore industries with access to international public telephone (more than 40 channels) and telex networks, and with facsimile and data transmission facilities. As a unique feature, they include a provision for handling priority messages for maritime distress and safety services.

KU-BAND SATELLITES

RCA Astro-Electronics are to design and build three high-powered communications satellites for use beginning in 1985.

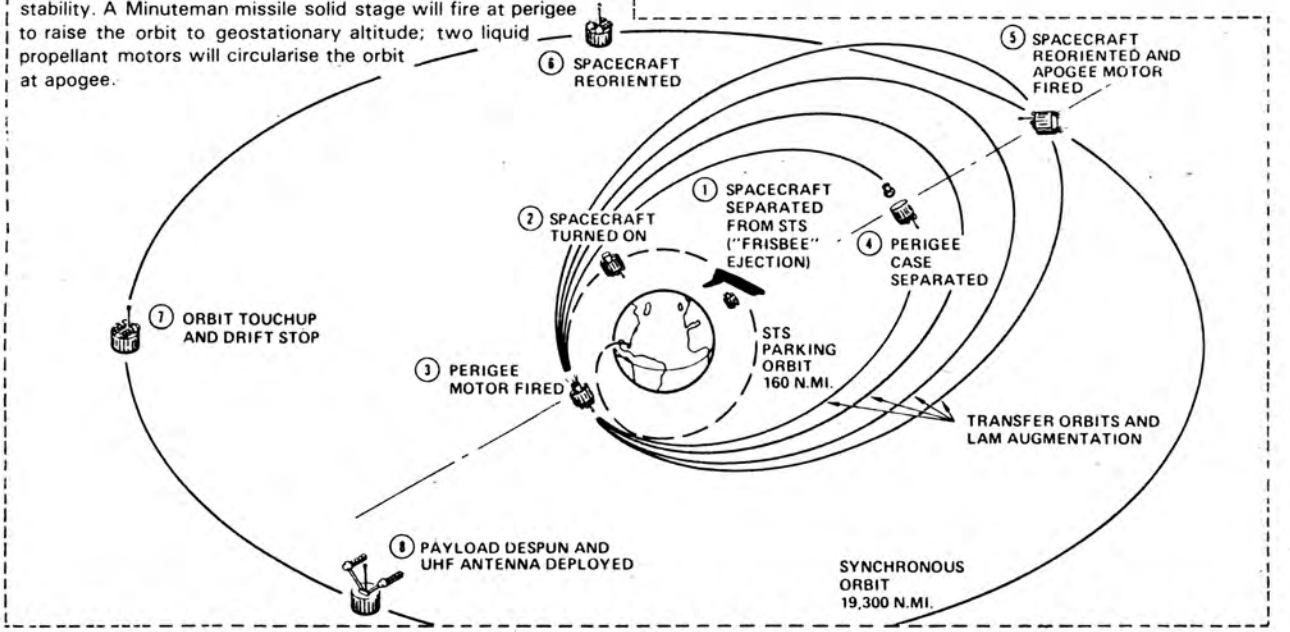
The three Ku-band satellites, to be produced for RCA American Communications Inc., will provide more efficient and reliable distribution of TV services to customers in major metropolitan areas. The first of this new generation is scheduled for launch in 1985. The Ku-band system's other two in-orbit spacecraft are expected to be in position by 1987.

"These satellites represent a high performance approach to satellite designs through the use of space-proven lightweight, cost-effective component designs based on the highly successful RCA Satcom domestic communications satellite system," said Charles Schmidt, Division Vice President and General Manager at RCA Astro-Electronics.

The new satellite system will allow distribution of televison programmes via one small rooftop antenna throughout a building. This service will be of particular benefit to apartment complexes, hotels, hospitals and office buildings in metropolitan areas and in regions where cable TV is not available.

The new satellite's increased signal strength will allow the use of smaller antennae which can be situated on top of buildings in urban areas. Also, the frequency of the Ku-band transmission is subject to minimal interference from terrestrial radio signals such as microwaves.

As described on p.253 of June's "Space Communications" section, the Shuttle will orbit several Leasat widebody communications satellites for the US Navy next year. British Aerospace are building the launch cradles. As shown in the diagram below, the satellites will be spun up before release for stability. A Minuteman missile solid stage will fire at perigee to raise the orbit to geostationary altitude; two liquid propellant motors will circularise the orbit at apogee.


6 SPACECRAFT REORIENTED
5 SPACECRAFT REORIENTED AND APOGEE MOTOR FIRED
1 SPACECRAFT SEPARATED FROM STS ("FRISBEE" EJECTION)
2 SPACECRAFT TURNED ON
4 PERIGEE CASE SEPARATED
7 ORBIT TOUCHUP AND DRIFT STOP
STS PARKING ORBIT 160 N.MI.
3 PERIGEE MOTOR FIRED
TRANSFER ORBITS AND LAM AUGMENTATION
8 PAYLOAD DESPUN AND UHF ANTENNA DEPLOYED
SYNCHRONOUS ORBIT 19,300 N.MI.

WILL YOU BE AT SPACE '84?

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The Future of Mankind	Ways and Means

This range of exciting topics will make it an event not to be missed. Attendance will be limited to a total of 400 members and guests, to retain that familiar, friendly atmosphere that everyone enjoyed so much at Space '82. Registration forms will be sent out towards the end of the year. Apply to the Executive Secretary, 27/29 South Lambeth Road, London, SW8 1SZ, England.

NEW "SOVIET ASTRONAUTICS" JBIS

The February 1982 *JBIS* issue devoted to "Soviet Astronautics" was so popular that it sold out within a few months. Now there is a second Soviet journal, largely filled with papers arising from the Society's Soviet symposium in early June, with another to follow if the material warrants it.

Contributions include an analysis of the Soyuz spacecraft, cosmonaut selections, Salyut progress report, Soviet spacecraft masses, communications satellites, nuclear powered satellites and others.

This new "Soviet Astronautics" issue is available at £2 ($4) per copy; simply ask for the October 1983 *JBIS*.

September's Journal concentrates on "Space Technology", with papers on space stations, collecting micrometeorites, the European Remote Sensing satellite and aeroassisted orbit transfer. Again, individual copies may be purchased for £2 ($4) each, from The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England. Two special issues to follow are "Astronautics History", edited by space historian Mitchell Sharpe, and "Halley's Comet", reviewing the comet's history and how we will investigate it during its new appearance. Both may be ordered in advance.

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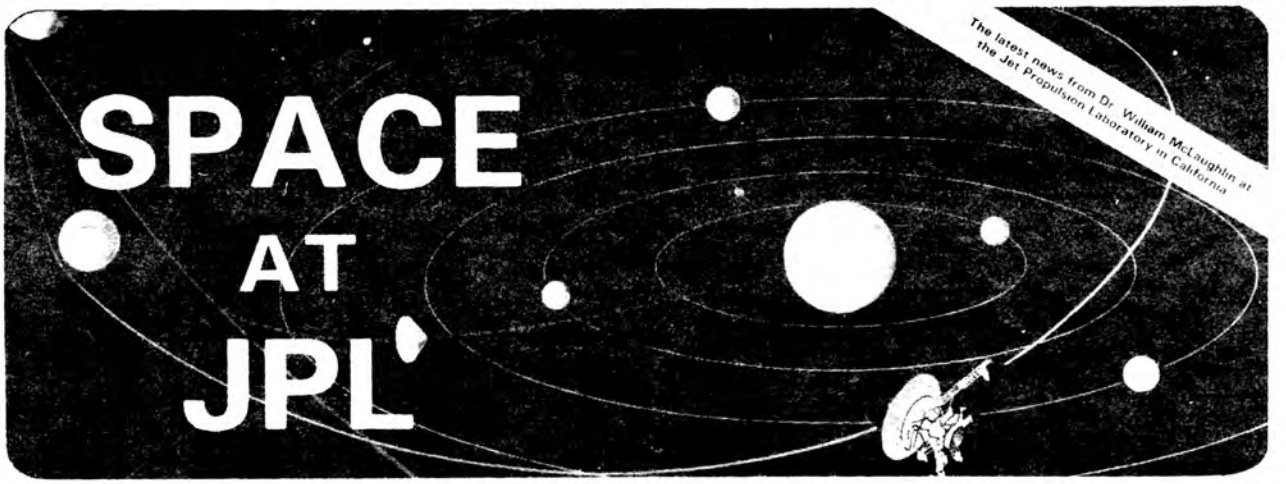


NEW PLANET-CROSSING ASTEROIDS

A newly-discovered asteroid passed relatively close to Earth on 7 July, according to a team of JPL astronomers who recently have found three asteroids.

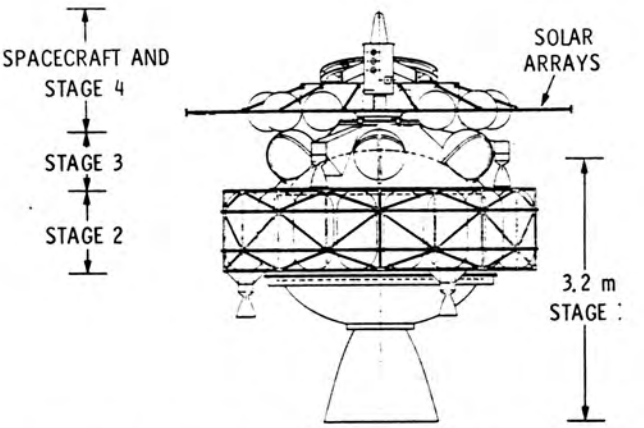
Planetary scientist Eleanor F. Helin and colleagues report that the near-approaching asteroid, designated 1983LC, passed about ten million km from Earth. Only a few other asteroids are known to have come as near in recent years. The astronomers discovered the asteroid and two others, 1983LB and 1983LD, during a continuing search for fast-moving objects in the night sky. The discoveries appeared on photographic plates taken the night of 12–13 June with the 48 inch (122 cm) Schmidt telescope at Palomar Observatory.

Object 1983LC is a member of the Apollo class of asteroids, which periodically cross Earth's orbit. Preliminary calculations show that it may be one of the smallest Earth-crossing asteroids ever seen, being less than a kilometre in diameter. Asteroid 1983LB has been classified as a member of the Amor class. Amors are Mars-crossing asteroids that closely approach Earth but only occasionally come near enough to cross our orbit. Closest approach for 1983LB is estimated to be at a distance of approximately 50 million km. The third object, 1983LD, is distinguished by a high orbital inclination of 19 degrees. It falls into the inner region of the "main belt" of asteroids between the orbits of Mars and Jupiter. Of the approximately 5,000 known asteroids in the Solar System, only 55, including 1983LB and 1983LC, cross or approach Earth's orbit.

Discovery of 1983LC and 1983LD is credited to Helin and colleague R. Scott Dunbar, who together obtained the discovery plates while conducting their work for the Planet-Crossing Asteroid Program, a systematic search begun in 1973.

TWO STONES WITH ONE BIRD

A dual mission, using one spacecraft to go to two Solar System targets, is the subject of this month's advanced-concept review. Significant cost savings could be obtained by using a single spacecraft and operating system to investigate more than one body: the Moon and Mars or the Moon and an asteroid are



A conceptual design for a spacecraft to visit two Solar System bodies, such as the Moon and Mars, in one mission.

NASA/JPL

favoured targets in a study conducted by C. W. Uphoff (who must take responsibility for the title of this section!) and J. R. Stuart of JPL and R. E. Glickman of Ball Aerospace Systems Division. Like all of the advanced-concept studies, such a mission has not been funded but is a candidate for future development.

Of course, several previous missions have encountered more than one Solar System body during their lifetimes, e.g., Voyager, Pioneer, Mariner Venus-Mercury, and Viking (Mars, Phobos, Deimos). Galileo will investigate not only Jupiter but also the Galilean satellites, and the Soviet Halley probe will also travel to Venus. However, none has orbited two bodies (apart from the trivial case of the heliocentric transfer orbit prior to planetary encounter). The Uphoff-Stuart-Glickman study seeks to exploit previous experience, present technology and current science interests to derive attractive low-cost missions.

One scenario for a Moon-Mars mission would begin with a 470 kg spacecraft carried into low-Earth orbit by the Shuttle. The spacecraft would then be lifted toward the Moon by an Intelsat VI communications satellite perigee motor. After going into a 100 km polar lunar orbit, a mapping of the Moon would be conducted for one year. Remote sensing of the lunar equatorial regions, whose composition is reasonably well-known from the Apollo samples, would help to calibrate the

spacecraft's instruments in preparation for the investigation of the lesser-known Martian surface. The higher lunar latitudes, which have not been as thoroughly investigated, would yield new science. After completion of lunar operations the trip to Mars would require six to eight months, and a mapping of Mars from a 550 km orbit would be undertaken. Thus, the total mission duration would be approximately 3½ years.

A dual mission to the Moon (in 1993) and the asteroid Euterpe (in 1994) would require a Martian gravity assist for the trip from the Moon to Euterpe to supplement the propulsion system under consideraton. A dual mission to the Moon (in 1989) and the asteroid Flora (in 1990) would have more severe energy requirements, and a dual gravity assist from Mars would be required. Many other Moon-asteroid mission pairs are available.

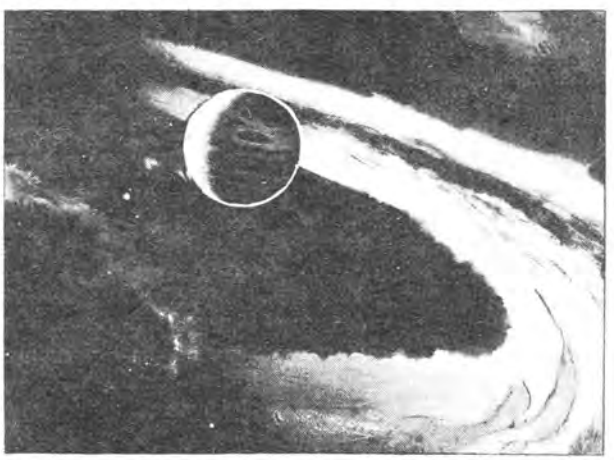
In summary, dual missions are attractive because they achieve data return from two objects while requiring only one launch, one spacecraft, one mission operations system and one data system.

GALILEO'S UV SPECTROMETER

The Galileo mission to Jupiter will be launched in late May 1986 to send a Probe into the Jovian atmosphere and place an Orbiter about the planet. During its 20 month tour of the system, the Orbiter will study Jupiter and the four Galilean satellites: Io, Europa, Ganymede and Callisto.

One of the instruments mounted on the moveable scan platform of the Orbiter will be the ultraviolet spectrometer (UVS). The UVS will operate in the wavelength range of 1150 to 4300 Ångstroms (one Ångstrom equals 10^{-8} m; visible light extends from about 4000 to 7000 Å).

The UVS will be able to measure ultraviolet emissions from the atmosphere of Jupiter, caused by the impact of charged particles and Sunlight. A search for complex molecules will also be undertaken using the UVS – acetylene has already been identified on Jupiter by ultraviolet spectrometry. It may be possible to identify complex hydrocarbons in the atmosphere; detection of these "building blocks" for life on Earth on another Solar System body would be a significant discovery.



A cloud of plasma swirls about Jupiter at the orbit of the satellite Io and may originate from volcanic outbursts from that body. This drawing shows the material as it would appear in the ultraviolet; in the visible a yellow glow from sodium would be apparent.

The UVS will also be used for observations of the Galilean satellites. One objective will be to look for evidence of atmospheres created by escaping volatiles. In addition, the UVS will be used to analyse the cloud of ionized sulphur and oxygen that encircles Jupiter along the orbit of Io. The cloud probably originates from volcanic activity on Io and interacts with the magnetic field of Jupiter.

The Principal Investigator for the 4·2 kg UVS is Dr. Charles W. Hord of the University of Colorado. Galileo is managed by JPL for NASA.

PLANETARY IMAGE VIDEO DISCS

Technologies for information storage have, of course, burgeoned rapidly in recent years. None has been more dramatic than the ability to compress a large number of visual images onto a compact video disc.

In the November 1982 "Space at JPL" the Regional Planetary Image Facility at JPL was described, along with the video disc upon which much of their material is stored. Now copies of this disc are available for $50 each ($80 outside of the North American continent) through the National Technical Information Service (NTIS). The address is: NTIS, 5285 Port Royal Road, Springfield, Virginia 22161, USA. The order number is PB83-223131.

Basically, the video disc contains many of the images returned by US planetary missions during the 1970's: 100,000 black and white images are stored on the two-sided disc. Included are Viking Orbiter and Lander products, scenes from Mariners 9 and 10, and Voyager images of Jupiter and its satellites. Some coded descriptive material accompanies each image, but the disc is intended more for use by planetary scientists rather than as display material for the general public.

A second video disc, of a more popular nature, has been prepared by JPL's Public Information Office and is available for the same price from NTIS. It consists of selected material from the last 20 years and has, in addition to colour and black-and-white still photos, movies on Ranger, Surveyor, Mariners, Viking and Voyager; some are sound, some silent. The sequence featuring the final descent of Ranger 7 to the Moon is particularly dramatic. The order number for this disc is PB83-223123 from NTIS. (Note: JPL does not have any video discs available for distribution.)

SPACE STATION STUDIES

The involvement of JPL with the Apollo project was primarily through lunar reconnaissance, as exemplified by the Ranger and Surveyor projects. The Laboratory has been involved with the Shuttle mainly as a user: employing the vehicle as a platform for instruments such as a synthetic aperture radar (SIR-A) and, in the future, as a launcher for satellites (Extreme Ultraviolet Explorer) and interplanetary spacecraft (Galileo).

Now, with the possibility of the Space Station

becoming NASA's third, great manned effort, JPL has assumed a more active role in project design through the formation of a Space Station Office.

Because of its interest in using the Space Station for science and applications and to ensure that the station is "user friendly," JPL has become active in the definition phase and later may participate in some aspects of its implementation. A Space Station Task Force was established in early 1982 by NASA Administrator James Beggs to conduct a three-year review and analysis before any possible development activity. Current thinking envisages a *modular* Space Station so that it can easily evolve as required from a relatively small facility which could be in orbit by 1991.

JPL personnel are participating in all aspects of the current NASA studies, with about $7 million worth of work this year. The JPL Space Station Office is managed by Donna L. Pivirotto, who foresees numerous benefits from an operating Space Station. Servicing of Earth-orbiting astronomical satellites, such as Space Telescope, would be facilitated by a station, and the biological sciences would benefit from a weightless laboratory for experimentation. A major application of the station for JPL projects would be its possible use as a primary launch site for deep space probes. It would allow on-orbit assembly of spacecraft and booster combinations whose total mass was greater than the Shuttle payload capacity.

Although Space Station has not been funded beyond the study phase, this effort might eventually transcend even the most important of its applications by forming a bridge for the colonization of space.

VERSATILITY

Astronomical subjects have been celebrated in verse from the earliest recorded poems, e.g., Homer's line "Arctos, sole star that never bathes in th' ocean wave," to a more recent allusion by Adrienne Rich, "The radio impulse/pouring in from Taurus". Richard Allen's delightful book *Star Names, Their Lore and Meaning* is sprinkled with lines from classical poetry, while Laurence A. Marschall's "Modern Poetry and Astronomy" in the March-April 1983 issue of *Mercury*, published by the Astronomical Society of the Pacific, focuses on our century.

Astronautics is not old enough to match astronomy in the quality of quantity of its associated verse, but space engineers have been doing their bit. Successful projects tend to produce vigorous ballads. Witness this sample from the Laboratory's Mariner 10 mission to Venus and Mercury, launched in 1973 (MVM'73). The seventh of 14 verses written by Donna Pivirotto addresses ironically the public excitement generated by television (T.V.). images from the spacecraft compared with nonvisual experiments, such as those performed at radio wavelengths by the Radio Science Team. The high gain antenna (HGA) of the spacecraft was an integral part of these experiments.

"Radio Science is quite an alliance on MVM'73,
Horrendous requirements and many desirements
proliferate quite merrily.
Their Earth occultations create real sensations,
'Let's slew the HGA, wheel'
But they're deep in despair, no-one knows they're
there for the news only cares for T.V."

Chorus:
"MVM'73, MVM'73, they're deep in despair, no-one
knows they're there on MVM'73."

When in the course of the IRAS project Gene Giberson left his position as project manager to assume other duties (then JPL Director Bruce Murray appointed him Assistant Laboratory Director for Flight Projects), a poem was forthcoming to mark this change, with a last verse,

"But now the winds that blow from east to west
Have set the planet-program quite a test
Once more the call from Bruce is loud and clear
Whence Gene must go, but have no fear
In common sense and costing by computer
Mayhap he'll brush a comet tail or even land on
Pluter."

Subsequently, Giberson's successor, Jerry Smith, moved on to manage the University of California's 10 m telescope project, and more verse was forthcoming:

"The skill of the Smith's modern anvil and hammer
Forged dewar and JFETs in the best systems manner.
And IRAS maps gas in the cosmic arena
(Quite like the air swirling through Pasadena)."

The acronym JFET refers to "junction field-effect transistor," which is a key part of the IRAS focal plane. Modesty prevents me from naming the author of these IRAS pieces, but his deft and supple fashioning of these lines should be hauntingly familiar to all regular readers of this column (may Shakespeare and Milton forgive me!).

At the Society's Space '82 event in Brighton I presented a paper, subsequently published in the May issue of *JBIS*, entitled "Pathways of Evolution for Man and Machine". The thesis of the paper is that man is likely to be replaced in the evolutionary sequence by intelligent machines. In conjunction with this conclusion, my colleague Michael R. Gilmore, an engineer at TRW, has composed the poem "Darwin, Von Neumann, and HAL" with which this section concludes.

Will life's helix build in space
A freer soul, another race?
New flyers, runners, robots, fish –
The next age from a petri dish?

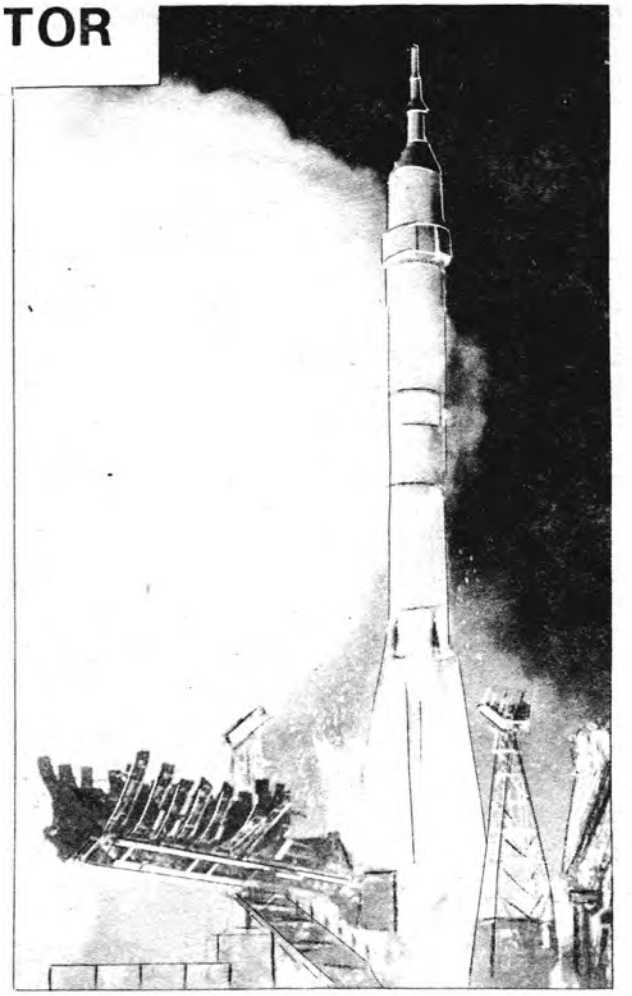
The sacrament of life was cast
In crumbling molds that did not last;
By chance this art, in flesh and bone,
Was varied, be it dove or drone.

But now we recombine and cut
New plans beyond the brain and gut;
We next dismiss some spark divine –
The circuit and the gene combine.

So now, as long ago was told,
A new god comes in flesh and gold:
The son of Man, creature biazarre,
The product of a seminar.

THE COSMOS CALCULATOR

By Nicholas L. Johnson*

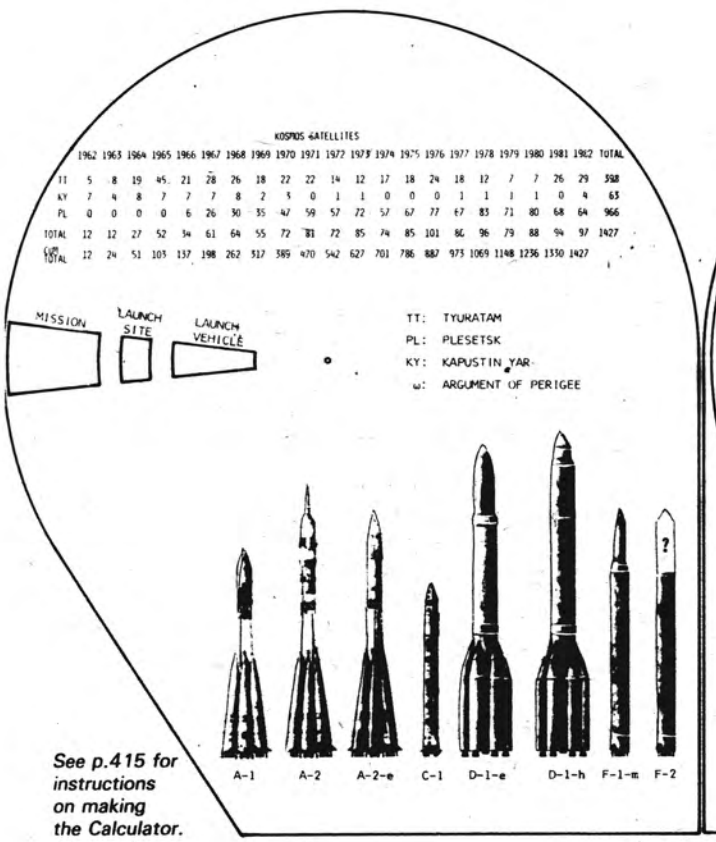


Since 1970 the vast majority of satellites orbited by the Soviet Union have come under the ubiquitous Cosmos programme. This series was inaugurated on 16 March 1962 for the announced purpose of studying the upper layers of the atmosphere and outer space. In point of fact, Kosmos satellites have fulfilled a gamut of civilian and military missions, from communications and meteorology to navigation and surveillance. By the end of 1982 Cosmos had fostered 1427 satellites. Specifically, during the period 1970–1982 Cosmos satellites accounted for 80% (1110 of 1386) of the spacecraft launched by the Soviet Union.

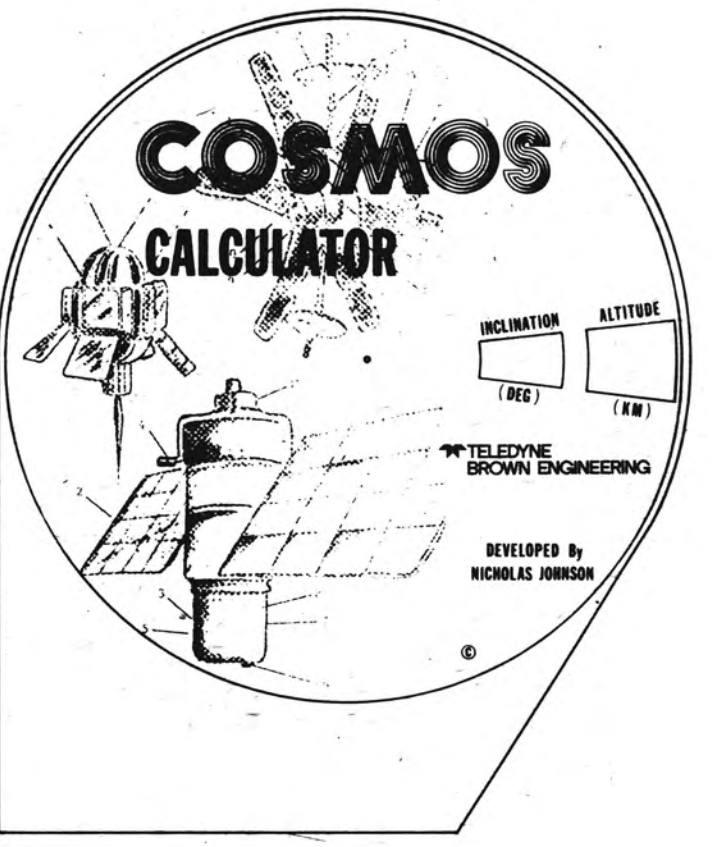
A typical Cosmos launch announcement reveals little more than the Cosmos number and the satellite's basic orbital parameters. For example, below is the TASS announcement accompanying Cosmos 1428, the first Soviet space launch of 1983:

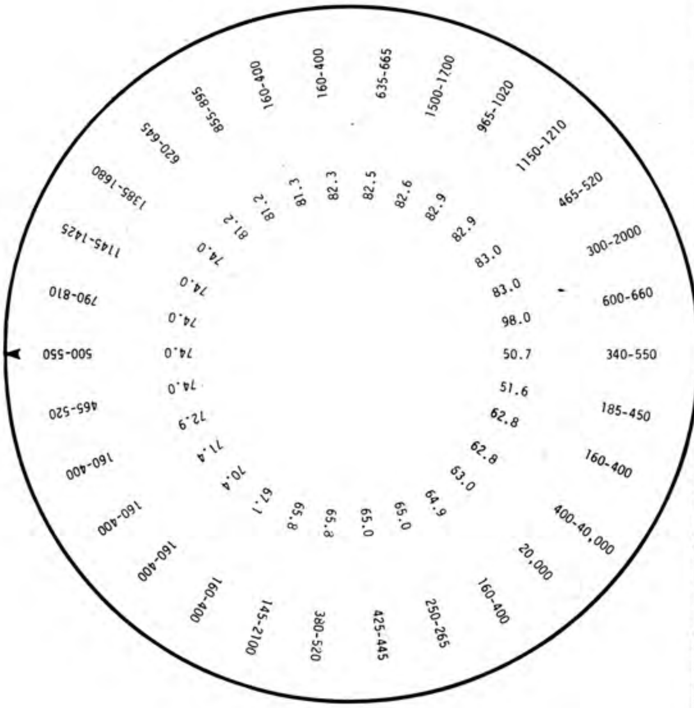
> "Moscow, January 13, TASS – The artificial earth Satellite Cosmos 1428 was launched in the Soviet Union on Wednesday.
> 'The sputnik carries scientific equipment designed to continue the space exploration programme.
> "The sputnik was put into an orbit with the following parameters: the initial period of revolution – 104.7 minutes, the maximum distance from the surface of the

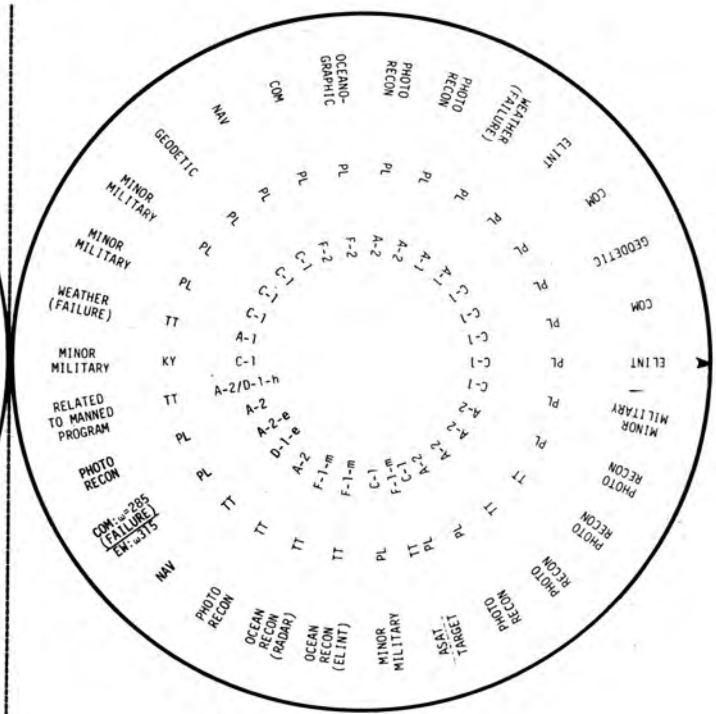
Principal Technologist, Teledyne Brown Engineering, Colorado Springs, CO, USA.



See p.415 for instructions on making the Calculator.







earth – 1,017 kilometers, the minimum distance from the surface of the earth – 972 kilometers, the inclination of the orbit – 82.9 degrees.

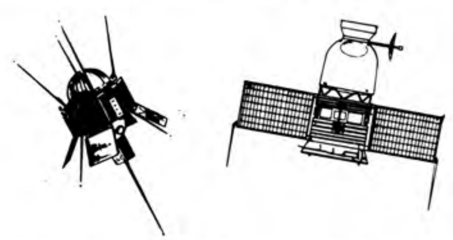
"Aboard the sputnik there are a radio system for precise measurement of the elements of the orbit, a radio telemetric system to transmit back to earth data on the operation of instruments and scientific equipment.

"The equipment installed aboard the sputnik is functioning normally. The coordination-computing center is processing the incoming information."[1]

In this case the probable mission of the spacecraft is left to the imagination and resources of the reader. Nowhere is there a hint that Cosmos 1428 is a navigation satellite (of the US Transit class) which replaced Cosmos 1333 orbited just a year earlier. Fortunately, the pioneering work of Dr. Charles Sheldon, Geoffrey Perry, and other analysts of the Soviet space programme have laid the groundwork for easily identifying the probable missions of most Cosmos satellites.

By comparing the orbital parameters and flight characteristics of Cosmos satellites with American satellites possessing similar properties and by employing a little scientific reasoning, families of Cosmos satellites have been assigned likely missions. Over the years many of these assignments have been verified by either Soviet announcements or statements by American officials.

The Soviets have cooperated in this effort by strictly adhering to launch practices which virtually produce a calling card imprinted with the site of origin, launch vehicle and payload mission. For example, the orbital inclination of a satellite (with rare exceptions) is characteristic of a specific launch facility [2]. The majority of medium inclination photographic reconnaissance satellites coming out of Tyuratam have flown at 51.6°, 64.9°–65.0°, 70.4°, and 71.4° inclinations while those launched from Plesetsk are inserted in 62.8°, 67.1°, and 72.9° inclinations. This practice may be the result of range safety constraints as the rockets are guided away from populated areas during their boost phase. In addition, in the case of the A-class vehicles which reportedly rely on radio navigation



during their ascent, the placement of ground stations may also dictate launch azimuths.

In a similar vein, different launch vehicles fired from a specific site often follow different azimuths. C-class vehicles coming out of Plesetsk enter 65.8°, 74.0°, and 82.9°–83.0° inclinations, whereas A-class vehicles from this site utilise 62.8°, 67.1°, 72.9°, 81.2°–81.3° and 82.3° inclinations [3].

The final pointer, however, is the combination of orbital inclination and altitude regime. A Soviet Spacecraft orbiting the Earth at an inclination of 74° almost certainly came from Plesetsk atop a C-1 launch vehicle. If the initial altitude varies between 465 and 520 km, the mission has been assessed as minor military (i.e. radar calibration, C^3 testing, etc.); but if the satellite takes up residence between 500 and 550 km, the mission may be electronic intelligence (ELINT). Likewise, higher flying satellites in the 790–810 km and 1400–1700 km ranges at 74° are thought to perform communications functions.

All these characteristics have been considered in the design of the Cosmos Calculator which appears here. It was developed to permit quick distinction of the three primary Cosmos satellite identifiers: mission, launch site and launch vehicle. The device is currently in use in many countries around the world by enthusiasts and professionals alike. After constructing the Cosmos Calculator (as described at right), turn the inner disc until the most appropriate combination of altitude and inclination for the Cosmos satellite in question is visible. Then flip the Cosmos Calculator over to determine its other characteristics.

Instructions for Making the Cosmos Calculat

1. Carefully cut out the two printed sections m this magazine. If desired, they can be stuck on ligl :ard to provide strength.
2. Fold the disc section in half along the dotted l ›. Cut around the disc and secure the two halves witl ɔaste or transparent tape. Be sure that the alignment a ·ows opposite the fold meet.
3. Fold the cover section in half and cut around the out'ine. Be careful not to cut the fold joining front and back. Unfold and cut out viewing windows.
4. Insert disc into Cosmos Calculator, ensuring the data are visible through all windows.
5. Fasten Cosmos Calculator together with a brad or similar fastener in the centre.
6. Tape the Cosmos Calculator along the bottom.

REFERENCES AND NOTES

1. Foreign Broadcast Information Service, 14 January 1983, Vol III, No. 10, P. U1.
2. A modern exception was the unique flight of Cosmos 1426 from the Baikonur Cosmodrome in late December 1982. Cosmos 1426's orbital inclination of 50.5° was almost identical to the 50.7° missions orginating from the Kapustin Yar launch complex. Another exception are the 65.8° inclination, C-class ASAT targets and calibraters which came from Plesetsk and the F-class ASAT's themselves which are launched from Tyuratam into the same inclination. However, this is a necessary condition since Soviet ASAT's make coplanar intercepts. In fact the Soviet ASAT inclination was switched to 65.8° when the C-class vehicles entered the programme. The inference is that 65.8° was a compromise inclination for the two different vehicles and two different facilities.
3. Another exception here are the A-class and D-class man-related flights out of Tyuratam. Due to the necessities of rendezvous, 51.6° inclinations are used by both boosters.
4. This edition of the Cosmos Calculator is reprinted with permission from *The Soviet Year in Space, 1982*, Teledyne Brown Engineering, Colorado Springs, Colorado, USA, 19ℇ3.

CELEBRATE OUR 50th ANNIVERSARY WITH US

This October will see the Society reach its 50th Anniversary – half a century of promoting space travel for the benefit of mankind. To mark the event, we are holding a celebration dinner at Society headquarters during the evening of Friday, 21 October 1983 for members and Guests of Honour.

The evening will be highlighted by the presentation of a Golden Jubilee Plaque by the American Institute of Aeronautics and Astronautics, messages of congratulations from around the world and – of course – the dinner itself.

The celebration is open to members, who may introduce one guest each. The cost is £15 per person, which covers an aperitif, a 4-course dinner and wine.

Why not join us to mark a significant event in the Society's history? Places are restricted so early application is essential.

If you would like to attend, please advise the Executive Secretary. Dress: lounge suits or dinner jackets (optional). Time 7.30 p.m. for 8 p.m.

We want as many members as possible to participate. Those who, for one reason or another, cannot make October 21st will have a further opportunity with an equally-exciting second banquet arranged for the following night. Please indicate if this is more convenient.

As a special souvenir to mark the Anniversary, a number of Orrey Clocks will go on sale to members. Further details will be announced later.

1933 50th 1983

ANNIVERSARY

THE OBJECTIVES OF SPACELAB 2

By John Bird

The anticipated success of the Spacelab 1 mission in October will pave the way for the later flights in the series. Spacelab 3 – curiously enough – will be the next to fly, with Spacelab 2 following in 1985. The author discussed the latter with Dr. Eugene Urban, chief scientist for the seven day mission.

Twelve experiments have been selected for Spacelab 2. They are in solar physics, astrophysics, astronomy, atmospheric physics, life sciences and plasma physics. Three pallets will carry most of these experiments in the Shuttle's payload bay (there will not be a pressurized module for astronauts as in Spacelab 1). Two of the experiments come from British establishments. The first is "CHASE" – the Coronal Helium Abundance Spacelab Experiment – which should accurately determine the amount of helium in the Sun's corona. This will help us to learn more on how the Sun produces its energy, as well as lead to a better understanding of the origin of the Universe.

The University of Birmingham experiment will use a telescope with its own pointing system to study X-ray emissions from clusters of galaxies.

Another high energy physics experiment is from the University of Chicago. It will determine the composition and energy spectra of cosmic ray nuclei using charge counters carried in a 4 m high pressurized cylindrical shell (clearly seen at the back of the payload bay).

In the area of plasma physics, a subsatellite called the Ejectable Plasma Diagnostics Package (PDP), will be released by the robot arm to observe the wake produced by the Orbiter 10 km away. The Orbiter will then fly back to grapple the PDP and the arm will install it back in the cargo bay.

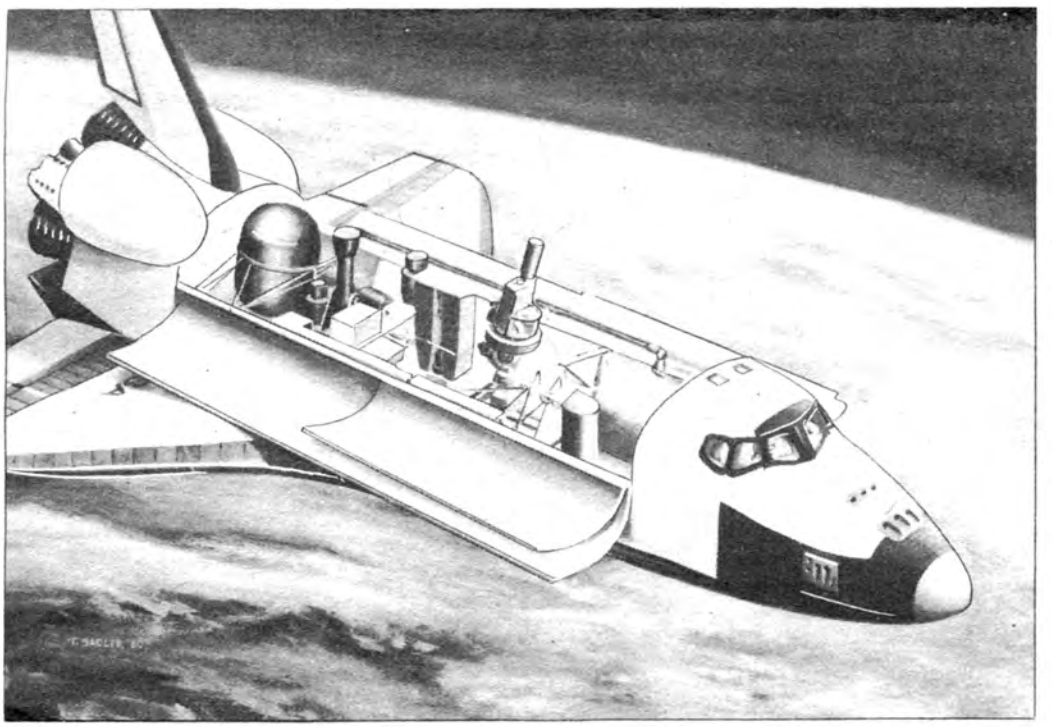
Another plasma physics experiment involves no onboard hardware but uses, instead, ground-based observatories around the world. The Plasma Depletion Experiments will observe the effect on the ionosophere of firing the Orbiter engines.

An infrared telescope will complement the measurements of the Infrared Astronomical Satellite. Spacelab's version, cooled with liquid helium, will observe diffuse emission and extended sources, although using the Shuttle as an IR platform might not be appropriate. It may be that such telescopes are better suited to flying free of the Shuttle, away from its heat emissions.

Future IR telescopes will use superfluid helium cooling as well, but its properties in weightlessness are poorly understood. For this reason, another experiment will concentrate on this aspect. Other space applications of superfluid helium involve superconducting magnets and gravitational wave detectors.

In addition to the UK solar physics experiment, there are three other solar-related investigations. The Solar UV Spectral Irradiance Monitor will be used to study ultraviolet radiation and its absorption in the Earth's atmosphere. The Solar Optical Universal Polarimeter is a telescope that will be used in conjunction with the Solar Magnetic and Velocity Field Measurement System. This experiment will study the Sun's magnetic field and transient events that can last a few minutes to a few days. Another solar telescope is the High Resolution Telescope and Spectrograph.

All four of the solar experiments will be mounted on an Instrument Pointing System (IPS), in use for the



An artist's impression of the Spacelab 2 mission in orbit. Problems with the Instrument Pointing System (seen under the long instrument towards the front) have delayed the flight until after Spacelab 3.

first time. It can provide more precise orientation than is possible with the Orbiter thrusters, keeping the four solar experiments aimed precisely at their target. The pointing stability was initially designed for sub arc-second accuracy, but predictions indicated it was actually 5 or 6 arc seconds, leading to redesign work and causing a major delay. Since it must change direction many times, the response speed was important but it did not meet specifications in this area either. The result is that Spacelab 3 will fly in September 1984 while the numerically earlier mission must wait for the following year.

The two life sciences experiments will examine the causes leading to bone demineralization and mineral imbalance observed in astronauts. Crew blood samples will be taken before, during and after the flight. Bone demineralization is of great concern. It appears to be a function of the time spent in space and does not level off. The other experiment will study the effect of weightlessness on plants.

In the accompanying illustration, most of the experiments can be seen in the cargo bay. The large cylinder at the back is the cosmic ray nuclei experiment. Mounted on the pallet furthest to the rear is the IR telescope and the PDP. On the next pallet is the dual X-ray imaging telescope. On the forward pallet is the instrument pointing system on which the solar experiments are mounted. Finally, in front of this pallet is a cylindrical container called an "igloo", used on all-pallet-only Spacelab configurations to provide electrical power and cooling for the pallets and associated experiments. The igloo is pressurized and temperature controlled.

Combining the disciplines of solar physics and astronomy has been a demanding task that will most likely be avoided in the future by dedicating each Spacelab to a group of experiments in a particular research area. For example, with a solar physics Spacelab, the instruments could be fixed on the Sun throughout the flight, rather than reorienting the Orbiter for assorted tasks such as atmospheric experiments.

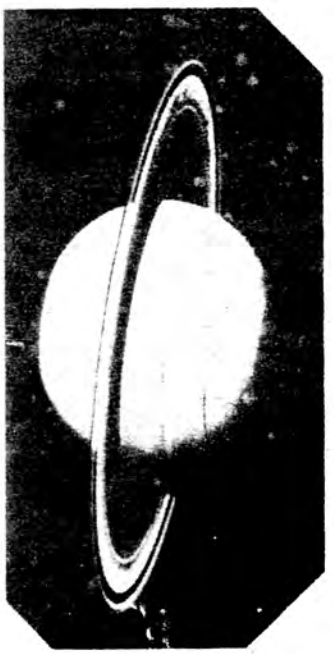
The Soviets were disturbed by a "Fast Electron Gun" on the flight so the name of the experiment was changed to "Fast Electron Generator".

Four Payload Specialists have been selected for the flight by the Investigators Working Group, made up of the mission scientists. The four (all Drs. and working in solar pyysics) are Loren Acton of Goddard Space Flight Center, John Bartoe and Dianne Prinz of the Naval Research Lab, and George Simon of the Air Force Geophysics Lab. Two of them will fly in the Shuttle along with two Mission Specialists and two pilots; the other two Payload Specialists will provide ground support.

Film Shows

THE DEPTHS OF SPACE

Man's knowledge of the Solar System has increased by leaps and bounds over the past two decades. Probes have penetrated in towards the Sun and Mercury, and Voyager 2 is now heading for distant Uranus with its retinue of five known moons



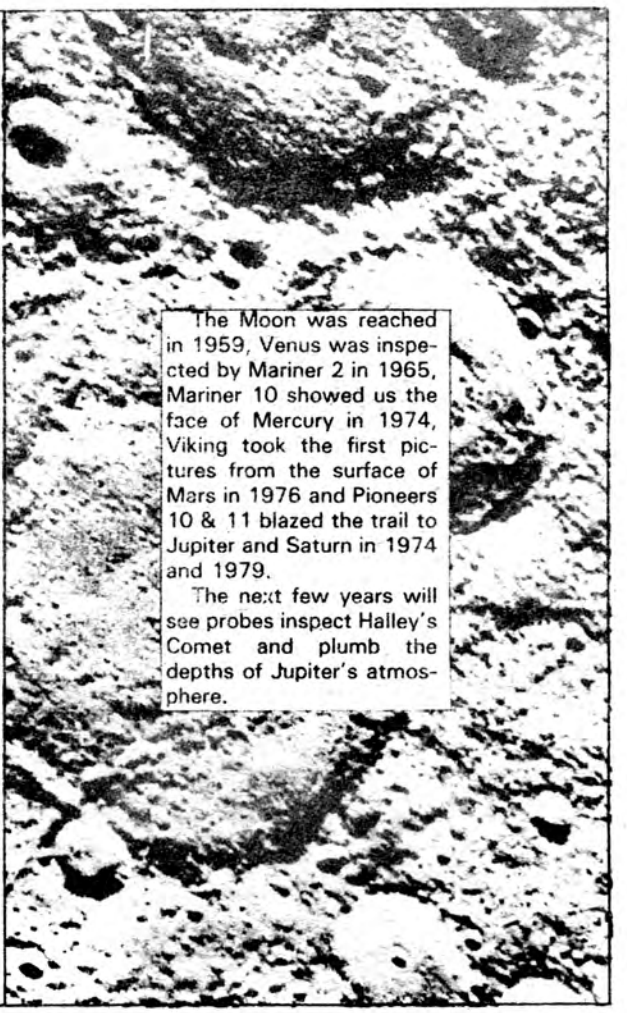
The two parts of this programme will cover these early years of our first steps into the depths of space. Part 1, on **9 November 1983**, 7-8.30 p.m. includes:

(a) Partnership in Space: Mission Helios
(b) Mercury: Exploration of a Planet
(c) The Clouds of Venus
(d) Meteosat

Part 2, on **30 November 1983**, 7-8.30 p.m. includes:

(a) The Planet Mars
(b) Exploration of the Planets
(c) Jupiter Odyssey
(d) Rotation of Jupiter
(e) Universe

Both parts will be screened in the Society's Conference Room, 27/29 South Lambeth Road, London SW8 1SZ. Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.



The Moon was reached in 1959, Venus was inspected by Mariner 2 in 1965, Mariner 10 showed us the face of Mercury in 1974, Viking took the first pictures from the surface of Mars in 1976 and Pioneers 10 & 11 blazed the trail to Jupiter and Saturn in 1974 and 1979.

The next few years will see probes inspect Halley's Comet and plumb the depths of Jupiter's atmosphere.

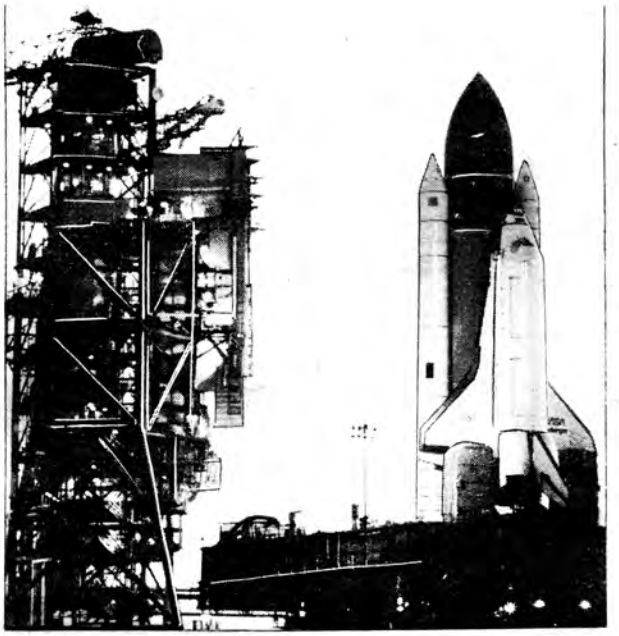
NEWS FROM THE CAPE

By Gordon L. Harris

SECOND SHUTTLE PAD

Boeing Services International have won a $17,800,000 contract to activate Launch Pad 39B and mobile launcher 3 for Shuttles. The second pad will be used in 1986 for the Galileo mission to Jupiter and the International Solar Polar experiment. On a somewhat smaller scale, a single storey cafeteria is being built next to the VAB; that in the Launch Control Center will be closed.

Boeing will continue performing ground systems operations for KSC *via* a $9,879,970 contract extension to September 30, 1983. This brought the cumulative value of the parent contract, now in its sixth year, to $327,775,920.



Shuttle *Challenger* was in position on 2 August for the STS-8 mission. *NASA*

SHUTTLE PRICES

NASA has announced a price schedule for Shuttle flights between 1 October 1985 and 30 September 1988. The fee of $38 million is fixed in 1975 dollar values. Adjusted for inflation, the cost will be about $71 million in 1983 dollars. Since most communications satellites are flown on a shared flight basis the 1986 fee for a Delta-class spacecraft will be $26 million, including an upper stage, while a Centaur class satellite will cost $41 million with an upper stage.

SPACE STATION NEARER?

NASA's prospects for a "permanent" space station brightened recently after the President's science advisor, George Keyworth, endorsed the plan. Administrator James Beggs told Congress that contracts for a station could be awarded within three years if the Administration and Congress back the project.

Beggs' appraisal was included in a five-year plan preliminary to submitting a Fiscal 1985 budget. He disclosed 11 Shuttle flights are planned in 1984 and 12 in 1985, when all four Orbiters are in service. His agency is negotiating now to turn over Delta and Centaur boosters to private industry after 1987.

Beggs estimated a space station will cost $6–$8 billion and will require an increase of 30 to 40 percent in NASA budgets or about one percent of the total Federal budget, $8.5 billion. The agency has $7.17 billion for FY 1984.

Supplementing Beggs' presentation, the Shuttle chief, Lt. Gen James Abrahamson, outlined current projects to enhance operations:

- A new type of spacesuit which could be donned immediately and worn for long periods. Presently astronauts must spend long periods of time in pre-breathing pure oxygen and cannot wear suits for more than 8 hours;
- A transfer vehicle to carry astronauts from Shuttles to a space station or other orbiting vehicle;
- An Aft Cargo Carrier, riding piggyback on Shuttle external fuel tanks, to increase cargo carrying capacity;
- An Orbital Transfer Vehicle (the "space tug") to lift cargo and astronauts from low Earth orbit to geosynchronous altitude. The OTV might be carried in that proposed Aft Carrier and left in orbit for reuse.

Abrahamson said that STS-17 in August 1984 will attempt to refuel a satellite in orbit, a technique essential for space platforms or other long duration missions.

NEW TELSTARS

Telstar 3, the first of a new generation of communications satellites, developed by American Telephone & Telegraph Corp., was launched by Delta 171 on 29 July from NASA's Complex 17. Two more Telstars will be carried in Shuttles over the next two years. Each can carry 93,800 conversations or 24 colour television channels. Telstar 1, flown in 1962, had a capacity of only 600 telephone circuits. Telstars will eventually replace the four Comstars leased by AT&T. The launch occurred on the 25th anniversary of President Eisenhower's signing the Space Act of 1958 which created NASA.

TAKING THE MICKEY

When the STS-7 crew returned to KSC after their mission to thank 2,000 NASA and contractor employees for their successful launch they suffered good-natured ribbing from KSC Director Richard Smith for their landing in California instead of the Florida base. Smith told the astronauts that KSC may have to fly its own crew to achieve a KSC landing, whereupon a space-suited Mickey Mouse climbed out of the astronaut van to present the fliers with watches.

WHERE IS EVERYBODY?

Tony Martin's and Alan Bond's "Is Mankind Unique?" article in June's *Spaceflight* has certainly aroused readers' interest. Our postbag has been weighed down with comments; here are a few, together with the authors' own in return . . .

Sir, Having read with interest the article by Anthony Martin and Alan Bond, I would like to add a few ideas which I hope will contribute to the discussion on the subject of extraterrestrial intelligence.

On reading this and other recent articles, I was left with the clear impression that the scientific community is in the process of another swing of opinion, this time to the view that life, or more precisely intelligent life, does not exist elsewhere in the Universe. Now there is no harm in the basis of opinion changing, but it does concern me that as one hypothesis replaces another so it is then readily accepted as fact and other hypotheses are rejected, even though there may be very little real evidence to support the new hypothesis. In the case of extraterrestrial intelligence the "evidence" is naturally mostly subjective. Worse still, the latest generally accepted hypothesis tends to be written up in the literature as if it was a statement of absolute truth. This has applied over the years to the theory of the origin of life, to the reason for the extinction of dinosaurs, to the formation of planets, even to the theory of evolution, and of course to the existence of extraterrestrial intelligence, where in the latter case we now seem to be in danger of going full circle.

So what can one say about the possible existence of advanced intelligence in space. I say "Yes, there is intelligence out there! Yes, the Earth has been visited! Yes, we are being kept under constant surveillance by 'beings' from outer space!" Then why, you may ask, hasn't the Earth been colonised by extra-terrestrials? Ignoring the desire to suggest that maybe it has, I prefer a much simpler answer. That is, for the same reason that man hasn't colonised the ocean floor or the land around the North pole. The conditions on Earth are so alien to those under which extraterrestrials live and there are so many other ideal planets for them to live on, that they don't need to colonise the Earth. So why don't we detect evidence of them through sightings, radio waves, etc? Again the reason is simple. They communicate with one another and also observe us using "Q-rays". And what are Q-rays? Well, I'm afraid that we haven't yet discovered them, and it will be a few hundred years yet before we do.

Before the reader dismisses all this as the ravings of a lunatic, let me quickly add that I put the arguments forward as an example of one of a number of reasonable hypotheses which can explain the positions we are in at present. Of course, I too, have no real evidence that this is the truth but some readers may agree that in essence it is a very plausible hypothesis. This line of argument does draw attention to another fault that we humans, and scientists in particular, have. That is, the belief that mankind has reached, or almost reached, the absolute boundaries of knowledge. Given some thought, we would have to admit that could we meet a man who lived 20,000 years ago, we would have great difficulty in communicating with him, but we tend to forget that in a few thousand years time (probably a lot less) we will seem just as primitive to men of that era as early man seems to us. We can't even begin to comprehend what another million years of development would do to our own species, let alone what life might be like under completely different conditions to the Earths' environment. And yet, if we don't make some attempt to understand the possibilities, we restrict scientific thought to too narrow limits.

Let us now consider the other side of the coin. In recent years, the popular notion, again often stated as if it was fact, has been that life exists in abundance throughout the Universe. This seems to be based on the observation that living things occur on this Earth and are therefore not unusual. We forget that the only reason we observe life on this Earth is that we exist. If we didn't exist, we obviously wouldn't make an observation at all. Indeed, we have here a sample of size one, and becuase it is of size one it tells us virtually nothing about life elsewhere in the Universe.

I wish to put forward yet another hypothesis to those mentioned by Martin and Bond, namely a "we don't know whether life exists elsewhere" hypothesis. I know that this doesn't sound very exciting, but it is surely the truth and I believe that at the moment we

should keep an open mind on this issue. We shall then be in a better position to judge the evidence, as it accumulates, for or against the existence of intelligent life elsewhere. I know that scientists (and many other groups, e.g. politicians) don't like admitting that they are in a "don't know" situation, but this is the reason that phenomena which doesn't fit in with existing theories are often ignored, as for example, in psychical research. Indeed, evidence is twisted and facts distorted in order to support the accepted version. Incidentally, do we really know that the Moon has been completely undisturbed for millions of years? Have we scrutinized very square metre of the Moon (including the far side) for evidence of disturbance, and would we recognise a disturbance even if we saw one?

I am not advocating that we give up debating the issue, or that we stop looking for evidence of life. We may not know whether life exists out there, but it should be fun finding out. Until we do, let us not discard any reasonable theory. Let us remember too, that a sample of size one may tell us very little, but a sample of size two may tell us nearly all. Certainly, a second example of a "living" planet would yield an immense amount of information about the origin, quality and purpose of life.

May I add one, perhaps more controversial comment, concerning the final few sentences of Martin and Bond's article. That is the claim that if we are unique, then we should be concerned about the responsibilities that the laws of chance and evolution have placed on us in preserving intelligent life on Earth. While I agree with the sentiment I cannot agree with the logic. Surely we are important only if someone or something outside our world or experience has made us important. If we are simply the product of chance, then such words as "responsibility" have no meaning as we are simply freaks of nature. Hopefully this is not the case.

I. G. BETTELEY
Lecturer, Department of Mathematics
The University of Aston in Birmingham

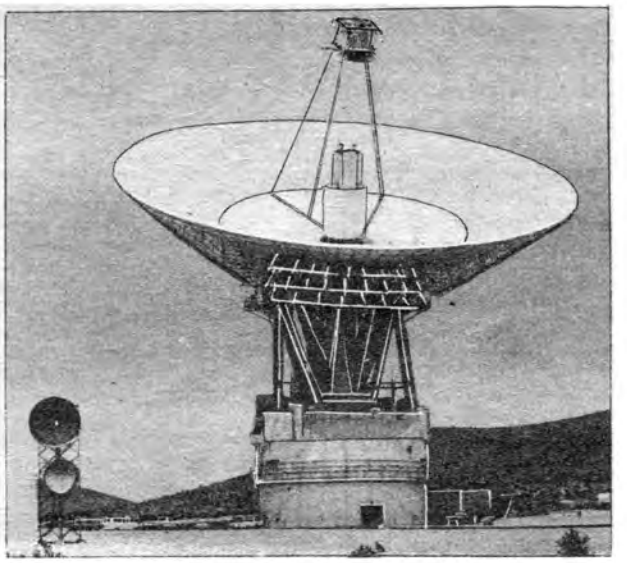
Tony Martin replies:

In his letter Mr Betteley makes some interesting observations, most of which I agree with. I can cross swords with him on several points, however.

Hypotheses change as a result of new evidence, or insight, or information, and also as a result of new approaches to a subject. However, as Betteley says, they remain hypotheses, not proven facts, and should be treated as such. His first alternative hypothesis, however, I would not class as "reasonable" as it involves an ad hoc assumption (Q-rays) for which there is no supporting evidence. It is less satisfactory, therefore, than the one that I have argued.

Regarding his second hypothesis, "We don't know whether life exists elsewhere", I am in agreement in the sense that it is not proven one way or the other. However, the formulation of arguments pro or con is a valid method of attempting to advance knowledge and further discussion – this is what I was trying to do in the paper at Space '82.

Betteley queries whether we have really looked



for evidence of extraterrestrial intelligent activity and whether we would recognise it. I think we have and would, but would welcome a comprehensive critique of this point – again pro and con. I am in complete agreement with the view that we should carry on searching, with a well-rounded, comprehensive programme involving all aspects of search, and that we should carry on debating at the same time.

His final point about "importance" and "responsibility" is a matter of one's philosophy. I would argue that if we are merely one civilisation among many others then we are not "important". However, if we *are* unique, or one of only a few, then we do matter and we should have a sense of "responsibility" to survive and prosper.

Sir, Having recently read the article "Is Mankind Unique?" I should like to draw your attention to another possible resolution of Fermi's paradox; one to which Martin and Bond do not give any serious consideration in their paper.

There are a number of possible ways in which an alien civilisation may be conceived to exist in our Galaxy and yet not to make its prescence visible to us. Martin and Bond follow Dr. Michael Hart in pointing out that none of these answers are viable unless necessarily applicable to every race of extraterrestrials, since otherwise one would expect even a single "one that got away" to have spread its influence throughout the Galaxy by now.

The following hypothesis, if correct, is indeed necessarily applicable to ever conceivable race:

> All expansionary civilisations, arising within any species anywhere in the Universe, are *intrinsically unstable*, and always collapse within a relatively short period of time.
>
> Conversely, the only durably stable social structure possible is one in which all expansionary and innovative activities are suppressed.

The idea has, of course, been considered before, Martin and Bond allude briefly to it, as does Iosif Shklovsky in Patrick Moore's *1980 Yearbook of Astronomy*; while, in *Extraterrestrial Civilizations* (1979), Isaac Asimov discusses similar ideas for ten

pages (208–217) before coming to the tentative conclusion that an Earthlike planet might support sucessive technological civilisations for some ten million years in all.

Where I differ from these writers is in believing that there are good psychological arguments from which the hypothesis may be derived, rather than simply going by the empirical observation that the human race is in a bit of mess.

Thus: the expectation that intelligent life should be fairly common in the Galaxy need not be abandoned in the face of complete absence of any signs of intelligent activity outside the Earth. For the intelligent activity, if it is indeed there, may exist in a situation dominated by outbreaks of war and periodic financial collapse, conditions which abort the growth of any civilisation before the stage at which a serious interstellar colonisation programme becomes feasible.

According to the underlying analysis, these conditions are inescapable by virtue of being generated, in the very nature of things, by any system composed of individuals in whom mind and matter coexist.

I would greatly regret it if Martin or Bond were to describe this idea as some form of "chauvinism"! For the scarcity of hard evidence, together with the complexity of the underlying psychological argument, makes it quite unsuitable as an object of fervent support. It is a hypothesis; no more and certainly no less. We might call it the *instability hypothesis*, and treat it as a tentative, though yet unrefuted, attempt at resolving Fermi's paradox.

STEPHEN ASHWORTH
Oxford

Tony Martin replies:

I certainly do not regard Ashworth's "instability hypothesis" as chauvinistic and indeed have argued this way myself on one occasion (*JBIS*, **32**, 424–434 (1979)). However, the fact remains that by itself it is not strong enough to explain the absence of extraterestrial activity in our Solar System. To do this, it must have the status of a "universal instability hypothesis".

It is not generally appreciated that Hart's argument that any resolution to the Paradox must be applicable to every case is a very constraining one. Anyone interested in this topic is urged to read C. E. Singer's paper in *JBIS* Interstellar Studies last year (*JBIS*, **35**, 99–115 (1982)), which discusses this in detail.

I have no wish or space to repeat Singer's arguments, but he considers a Galaxy with 100,000 civilisations which would undertake interstellar travel if they escape self-destruction. The lack of evidence for any such civilisation implies a probability of self-destruction of between 1 percent per year and 0.3 percent per day, depending upon how the probability is distributed.

ARE YOU MISSING OUT . . .

. . . on the information and excitement of *Space Education?*

The second of this year's *Space Education* issues includes a range of articles discussing the teaching, discoveries and philosophy of astronautics.

Arthur C. Clarke considers the impact of new communications technology, and Richard Lewis, whose book *The Voyages of Apollo* is perhaps one of the best covering the Moon-era, takes a backward view at the first US satellite a quarter of a century ago.

Other articles describe how to produce pictures of the Sun with simple equipment, how to demonstrate rocket propulsion in the classroom, and how to make the most of the BIS film service. The Society's visit to the Royal Greenwich Observatory is covered, with a description of the observatory's work.

Copies of *Space Education* are available at £2 ($4) each from 27/29 South Lambeth Road, London SW8 1SZ.

FROM THE SECRETARY'S DESK

Artistic Licence

From time to time the postman brings, unheralded, ideas for coats of arms, badges, medals, plaques, bookmarks, mottos and decals (stickers), all undoubtedly well-meant contributions for my edification and enlightenment.

Some are badly drawn or copied from elsewhere, but others are quite attractive. Nearly all have to be returned again forthwith but a few end up in our bottom drawer.

These saw the light recently to meet a requirement for a bookplate to be used for the Society's proposed archive material. There was only one runner, the bookplate sent in by Keith Page some years ago. Unfortunately, it didn't quite convey the idea of "age" so inspiration is still awaited.

However, we rediscovered the interesting design from P. G. Goodwin for a lapel badge or sticker depicting Daedalus. It is quite attractive.

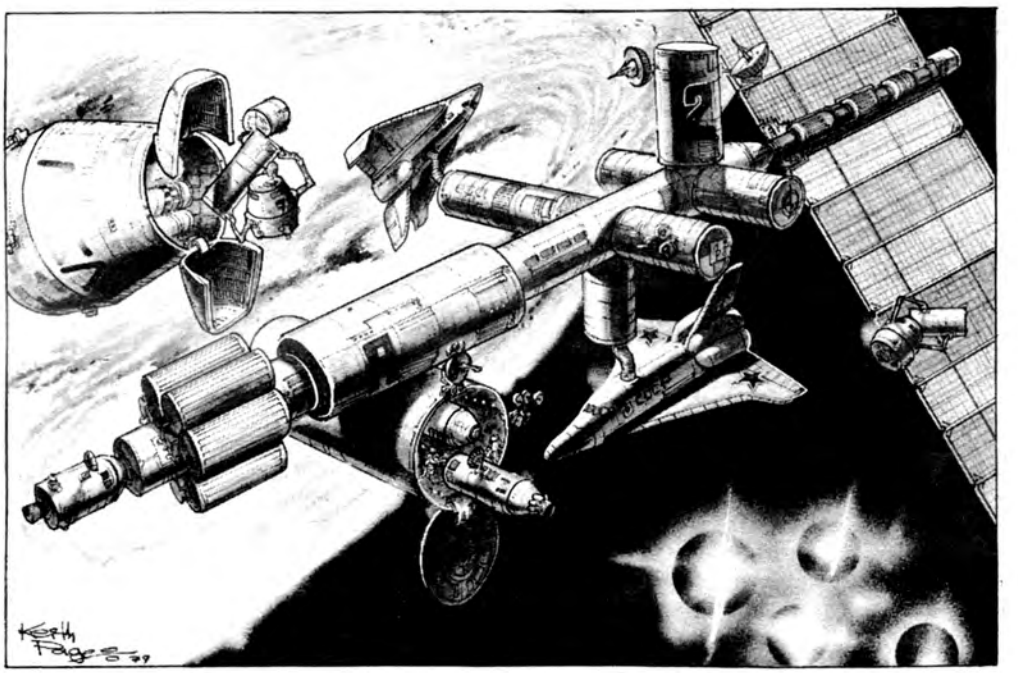
One intriguing idea, still on the Executive Committee's books, was for a drawing book for children. Most artists produce pictures which are far too detailed with the result that the children's water colours (if not the children themselves) aren't up to it. Keith emerged again with two drawings. Both had originally been submitted in black and white and both, presumably to teach him a lesson, had been sent back with the request that he colour them himself to prove it could be done. His results are shown, sadly in black and white rather than colour but, nevertheless, look very good. The problem preventing us from using Keith's work is one of marketing. The Committee is still looking for a partner on this side of it.

Our attractive Space '82 badge was designed by Kit Carson. He did this as a one-off contribution and hit the nail on the head straight away. We are still trying to persuade him to do a repeat for Space '84.

Fame & Fortune

There must be many anecdotes to do with appearances on TV. Some years ago I was involved in a magazine-type series which were particularly interesting because many entertainers, well-known today in the UK, cut their teeth on the same programmes. Some examples were Rolf Harris, Philip Harben and Mick and Montmerency, the former now better known as Charlie Drake.

At first rehearsal, it was decided that a star background would improve things. This was no sooner said than done. A workman appeared with a paint-spray



A Keith Page original, size 37 X 25 cm.

and set about spraying a very tolerable representation of the Milky Way on the screens immediately behind.

The next requirement was for a balloon, to show the principle of action and reaction. The plan was for me to release it and a camera would pan to catch it speeding across the front of the board, and thus seemingly into space. Some dummy runs made sure that everything would go well and, truth to tell, the effect was very good indeed. Unfortunately, catastrophe struck. Earlier that day I had seen a man walking around holding a fully blown-up balloon but this didn't appear very significant, given the other peculiar things going on. But the time came when the balloon had to be thrust into my hand to illustrate action and reaction and be ejected into outer space. Everything was fine. The camera panned along its allotted path to show the balloon speeding across a star background. But there was no balloon. Eventually it was found, by my right foot. The man holding the balloon all day had got fed up, tied up the neck and forgotten to untie it again.

That wasn't all. The programme included a commentary on early rocket experiments. Unfortunately, the monitor camera "died", leaving just a blank screen in the studio even though the actual film was still being televised. Just try giving a commentary on a film you can't see. The viewers must have been in stitches!

Hide & Seek

Playing hard to get are members who do not reply to letters for years at a time (currently we have 67 of them) yet continue to send us money by Bankers Order. There seems to be no way of preventing them from doing so; letters to their last-known addresses or c/o their banks have all yielded silence. It's very curious.

Conversely, sometimes members claim to have paid though we can't find anything from them. Sorting out problems like this can be like uncoiling a snake. Some are resolved easily e.g. the money intended for us was actually posted to someone else. But one, in particular, holds the record and remains unshaken to this day. It began with a money-order from Borneo.There was no accompanying slip or letter and the name of the remitter, when traced *via* the Post Office, was no-one we knew. It stayed a total mystery for months. Another dozen or so queries being dealt with at the same time included a member living in the UK who had detailed the date and place in Manchester where he had posted his letter, including counterfoils of postal orders which had been cashed. After a plethora of letters he suddenly remembered that he had actually given the letter to a friend to post. Once we knew the name of the friend, all the pieces fitted. The friend had not posted the letter but cashed the postal orders, gone on to Borneo, and sent the money from there under his own name!

Incidentally, some 400–500 members send in remittance slips each year without inserting their names and addresses. Usually there is no problem because an accompanying cheque helps us to make proper identification, though we always get about 15 payments by postal order each year with no clue as to who they came from. We have to attach up the envelopes and try to identify remitters later by the post-marks or handwriting on the envelopes.

Question Time

Even more devastating is the arrival of pages of poorly-written script containing up to 50 questions, beginning with "What should I do to train as an astronaut" and ending with the request for "a list of all satellites issued from 1957 to date, with full details of their purposes, who constructed them, results of the mission, etc."

One, which arrived a few years ago, requested the answers to only 15 questions. It was so nicely set out and the questions were so clear that, filled with the milk of human kindness, I scribbled replies to a few, intending to research the remainder later on. A later post the same day brought another six letters, all listing identical questions.

The secret was out. These questions had been set by a newspaper and first with the correct answers won a free trip to Florida. *Every* correspondent had failed to mention that little fact.

Word Processors

Even more progress took place with the long-awaited arrival of our word processors. Shirley Jones and Sue Mandry duly went off on a training course, returning later with the information that this had been only "basic". Their instructor, having realised what they were about, hastily disclaimed all practical help and murmered something about "more advanced courses," presumably on the grounds that our ideas were above our station and would push the equipment to the limit.

We referred to the instruction manuals but they didn't help much. The sheet headed "Static Electricity" indicated that both operators had to work with their shoes off or stay on rubber mats. Using the Visual Display Unit as a mirror while combing hair generally was also "out", so a wild and windswept look is part of our office scene nowadays. We are still very concerned about a section which talked about the possibility of being struck by lightning!

GIFT TO THE SOCIETY

The Council gratefully acknowledge the gift of £500 from Mr. Keith H. Otter as an initial donation towards the cost of extending the Society's premises.

Members who have been to HQ will have no doubt been readily aware that the need to extend both our Conference Room and Library will, one day, be thrust upon us, so the donation from Mr. Otter is a timely pointer to an exciting area of future development.

SATELLITE DIGEST – 167

Robert D. Christy
Continued from the September/October issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

COSMOS 1460 1983-43A, 14058

Launched: 0910, 6 May 1983 from Tyuratam by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with a spherical re-entry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6m, diameter (max) 2.4m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 350X417 km, 92.23 min, 70.34 deg

COSMOS 1461 1983-44A, 14064

Launched: 1030, 7 May 1983 from Tyuratam by F-1.
Spacecraft data: Not available but probably several tonnes mass.
Mission: Electronic reconnaissance covering ship movements.
Orbit: 429X444 km, 93.30 min, 65.00 deg

COSMOS 1462 1983-45A, 14071

Launched: 0810, 17 May 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1460.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package, recovered after 14 days.
Orbit: 259X277 km, 89.89 min, 82.32 deg.

COSMOS 1463 1983-46A, 14075

Launched: 1200, 19 May 1983 from Plesetsk by C-1.
Spacecraft data: Possibly cylindrical body with domed ends, enclosed in drum-shaped solar array with length and diameter both about 2m. The mass may be around 700 kg.
Mission: Not known but possibly geodetic.
Orbit: 300X 1550 km, 103.56 min, 82.94 deg.

INTELSAT 5 (F-6) 1983-47A, 14077

Launched: 2226*, 19 May 1983 from Eastern Space and Missile Center by Atlas Centaur.
Spacecraft data: Box-shaped vehicle with 16 m span solar array, mass around 1000 kg.
Mission: Communications satellite.
Orbit: Geosynchronous.

COSMOS 1464 1983-48A, 14084

Launched: 0250, 24 May 1983 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in a drum-shaped solar array with length and diameter both about 2 m, mass around 700 kg.
Mission: Navigation satellite.
Orbit: 968X1011 km, 104.92 min, 82.94 deg.

COSMOS 1465 1983-49A, 14087

Launched: 0500, 26 May 1983 Kapustin Yar by C-1.
Spacecraft data: Not available.
Mission: Either a radar test target or electronic reconnaissance.
Orbit: 349X543 km, 93.44 min, 50.66 deg.

COSMOS 1466 1983-50A, 14089

Launched: 1200, 26 May 1983 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1460.
Mission: Military photo-reconnaissance, recovered or re-entered after 41 days.
Orbit: 174X345 km, 89.68 min, 64.88 deg, manoeuvrable.

EXOSAT 1983-51A, 14095

Launched: 1518*, 26 May 1983 from the Western Space and Missile Center by Delta 3914.
Spacecraft data: Box-shaped body 1.35 m high and 2.1 m across housing satellite instrumentation and control equipment and the payload. Power is provided from a single solar panel on top of the vehicle 1.85 m high. Three axis stabilisation is by cold gas thrusters. The mass is 510 kg including 120 kg of scientific instruments.
Mission: X-ray studies including the precise location of X-ray sources using telescopes and observing occultations of sources by the Moon, mapping of low energy extended sources, studying variations in sources, X-ray spectroscopy and locating new sources.
Orbit: 356X191581 km, 5431 min, 72.46 deg.

COSMOS 1467 1983-52A, 14100

Launched: 1150, 31 May 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1460.
Mission: Military photo-reconnaissance, recovered after 12 days.
Orbit: 357X417 km, 92.31 min, 72.86 deg.

VENERA 15 1983-53A, 14104

Launched: 0240, 2 Jun 1983 from Tyuratam by D-1-E.
Spacecraft data: Basic vehicle is cylindrical with diameter about 2.5 m and length about 3 m, with a pair of solar panels. An instrument package is located at one end and may include a mapping radar. The mass is around 4000 kg.
Mission: Studies of Venus from orbit, including surface mapping by radar.

VENERA 16 1983-54A, 14107

Launched: 0240, 7 Jun 1983 from Tyuratam by D-1-E.
Spacecraft data: As Venera 15.
Mission: As Venera 15.

COSMOS 1468 1983-55A, 14110

Launched: 0750, 7 Jun 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1460.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package, recovered after 14 days.
Orbit: 252X277 km, 89.87 min, 82.34 deg.

OPS 6432 (3 payloads), 1983-56A, C & D, 14112, 14143 and 14144.

Launched: 0055, 10 Jun 1983 from Vandenberg AFB by Atlas.
Spacecraft data: Not available.
Mission: Ocean surveillance.
Orbits: Approx. 1045X1165 km, 107.4 min, 63.3 deg.

COSMOS 1469 1983-57A, 14123

Launched: 1215, 14 Jun 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1460.
Mission: Military photo-reconnaissance, recovered after 10 days.
Orbit: 231X342 km, 90.29 min, 72.84 deg.

ECS 1 1983-58A, 14128

Launched: 1159, 16 Jun 1983 from Kourou by Ariane (L-6).
Spacecraft data: Box-shaped body based on the OTS vehicle, height 2.4 m and diameter 2.2 m, mass (at launch) including the apogee boost motor and attitude control fuel, 1043 kg. Power is provided by a 13.8 m span solar array.
Mission: Provision of international telephone circuits covering Europe, the middle east and northern Africa; and distribution of television programmes in the same areas.
Orbit: Geosynchronous above 10° east longitude.

BIS SOVIET SPACE FORUM

The Society's Soviet space forum once again attracted considerable attention this year, with members writing in *before* the meeting to enquire when the papers would be published. The good news is that those unable to attend are to see the first collection in October's "Soviet Astronautics" *JBIS*, with another expected to follow.

The first session, on the evening of Friday, 3 June, was kicked off by Julian Popescu describing Soviet communications satellites and how they overcome the geographical difficulties of the USSR (five time zones, with coverage extending to Cuba!). The BBC's monitoring service uses a 10 m dish to receive signals from the Gorizont satellite stationed at 14°W above the equator, and trials with a 1·8 m dish demonstrated that it is possible for amateurs to put their feet up and watch Moscow TV.

C.P. ("Pat") Vick tackled the more military topic of Rorsats – radar ocean surveillance satellites powered by nuclear reactors for observing shipping movements. It seems that the satellites' useful lifetimes are dictated by the reliability of their reactors – the "Topaz" units can run up to at least 370d., while the satellites are averaging only 130d. The system – although the result of a 20 year effort – is still far from reliable and demonstrates that the Soviets have not developed solar panel technology sufficiently to replace the nuclear sources (the US scientific Seasat radar platform drew 1 kW from its solar panels, not too far below Rorsat requirements).

Phil Mills then presented a short description of the process for refuelling Salyut stations from the Progress tanker spacecraft. Delivering fresh oxidizer/fuel for manoevring to Salyut is a vital part of establishing a long-term space station – a step that seems to have been a complete success.

Julian Popescu opens the proceedings on the Friday evening with his paper on Soviet communications satellites. Behind the Speaker is a Skylark sounding rocket nosecone.

Some of 1983 Soviet forum authors. From left: P. Mills, R. Hall, P. Clark, C. P. Vick (from the USA), J. Popescu, D. White and A. Kenden.

Rex Hall's now-traditional summary of cosmonauts and their doings was again well received. The two papers arising from this presentation are included in October's *JBIS*. The final Friday evening paper reviewed the Soviet Union's giant launch vehicle programme, past and present. Pat Vick covered the original concepts of the Type G launcher, which never flew successfully, and continued his analysis to the newly designed giant booster which he is calling the Type L. The Type J is the provisional designation for the new intermediate launcher, capable of orbiting 12–13 tonnes, while the Type K system is the giant shuttle vehicle.

The second session began on Saturday morning and, following the pattern of previous years, films were shown to provide a break between the main paper sessions. This time the forum saw *Longer Roads to Space* and *People and Stars*, both covering the early part of the Salyut 6 programme.

After lunch on Saturday, two final papers were presented. Unfortunately, due to illness, Ralph Gibbons was unable to attend and his paper "The Evolution of the Vostok and Voskhod Spacecraft" was read by Anthony Kenden. The final presentation was Phillip Clark's "The Evolution of the Soyuz Programme". Taken together, they provided comprehensive overviews of the Soviet manned space programme, with speculation kept to a minimum.

A lively discussion session closed the meeting, with everyone agreeing that the 1983 event had been an unqualified success.

Copies of the October "Soviet Astronautics" JBIS are now available at £2 each ($4). The second issue, expected to be available early in the new year, may be ordered at the same time, enclosing the appropriate remittance.

CORRESPONDENCE

Soviet Shuttle

Sir, I refer to the letter on p.295 of the July/August issue and to the photographic feature in "Space Report" of the same magazine on the sighting of Cosmos 1445 by the RAAF in March 1983. The perfectly reasonable comparison between this Soviet shuttle test vehicle and earlier US vehicles was made in both cases, the letter referring to the US X-23 vehicle which flew in the 1960's.

An even more exact fit may, however, be gained by looking back at early European studies of lifting bodies. In the early 1970's the German ERNO "Bumerang" project saw the drop testing of sophisticated dummy spacecraft from aircraft. These tests (a success) involved a vehicle strikingly similar to the Cosmos vehicle [1].

There were reports at the time that the tests had been watched by two submarines of unknown nationality, and so we may perhaps consider the RAAF photography of the Soviet test as being a case of the biter bit [2]!

BOB SHAW
Glasgow

REFERENCES

1. *Flight International*, 14 January 1971, p.72.
2. *Flight International*, 23 March 1972, p.427.

Activity in Space

Sir, I am currently completing a detailed study of US space policy in the 1969–1972 period, when NASA's ambitious post-Apollo plans were rejected and the Space Shuttle apprpved. I was struck by the divergence between what NASA was proposing then and its current forecast for various achievements, as reported in J. J. Latapie's letter in the June *Spaceflight*. Compare what NASA proposed to the White House in September 1969 (the first figure) with what Latapie reports as the current milestones in an accelerated NASA program (2nd figure):

	1969	**(1983)**
Permanent Station (LEO)	1976	(1990)
Permanent Station (GEO)	1981	(2000)
Lunar Orbiting Station	1978	(2008)
Lunar Surface Base	1980	(2016)
Manned Mars Expedition	1983	(2010)

Let's hope that, in the next 14 years, these milestones don't recede another 14–37 years!

JOHN M. LOGSDON
Chair in Space History,
National Air & Space Museum,
Washington, D.C., USA

It should be noted that the dates given in Mr. Latapie's letter were unofficial *NASA estimates* — Ed.

Society Publicity

Sir, Members are undoubtedly keen to see the Society well publicised but, where this takes the form of Lectures, not all may realise that this can involve pain and suffering, or even loss of dignity.

Having given over 1,000 lectures on astronomy and space, I can recall, with some feeling, many occasions when this took place. Initiation was prompt. My first lecture was at a girls' school in Sidcup, speaking from a brightly lit stage to an audience in a darkened hall. Nervously, I walked up and down the stage. Unfortunately, I also chose to step backwards and fell off the back of the stage, out of sight. The chairs which had been stacked there came crashing down so the commotion was quite something, though my talk continued throughout, uninterrupted.

The second lecture was no less eventful. It took place in a public library. The front part of the audience consisted of elderly people who had come in out of the rain since the library provided a warm dry area ideal for a quiet snooze. It was devastating to find the front two rows occupied by people all dozing off.

Since the lecture was to be in two parts, I determined it would not happen again. I went out to buy a starting pistol and ammunition.

The second part, presented a week later, was quite different. I filled the pistol and, whenever I saw anyone dozing off, I changed the subject to action and reaction and, using the pistol as an example, fired it into that person's ear. Thereafter, I always carried a pistol when giving lectures.

Speakers face greater dangers than can be imagined. The raised dias, for example, may look innocuous but can contain a sea of leads, pipes and even the occasional trapdoor. Even the flower arrangements can be put in awkward places, so woe betide the natural fidget.

Plugs, too, are a problem. I learnt, very quickly, always to carry matchsticks so that, if the plug was missing, bare leads could be put into the sockets. This helped out on numerous occasions, *albeit* with constant exposure to electrocution. On one occasion, when a 20 minute search in a church hall failed to disclose even the semblance of a socket, the audience grew fidgety. There was no way out other than to go straight for audience-participation. A general appeal was made from the stage for all members of the audience to help us find the socket. They entered into the spirit of the thing with great delight. About 100 people searched and re-searched. They tore the place apart trying to find out where the projector should go. Eventually, the socket was found. It was up in the rafters, on an overhead beam!

Even acting as Chairman does not grant exemption. On one occasion I was an invited-Chairman at a USAF

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

Conference. Unfortunately, one of the papers in the session was classified and no-one had thought to get clearance for me. Consequently, the Chairman had to be escorted from the Hall while the rogue paper was presented and then solemnly escorted back to his seat of honour again when it was all over!

L. J. CARTER
BIS

SNIPPETS

Welcome Aboard
Sir, I note from the July/August issue that Space '84 is planned for 16–18 November 1984 in Brighton and I would be grateful if you could book me one place. This may be a bit premature but it pays to "book early and avoid disappointment"!

SALLY LORD
Bedford

Congratulations on being the first applicant!–Ed.

Where to Now?
Sir, All power and glory to the British Interplanetary Society for its second 50 years! Maybe its headquarters will be based in space by then for a number of economic or biological reasons?

GENE EMME,
Maryland, USA

We hope not!
Sir, In the computer trade paper *Computer Talk* a recent article discussed how the breakfast TV weather pictures were received. It included the following gem:

"Meteosat is in geostationary orbit 22,000 feet above the Greenwich meridian"!

P. J. PARKER
Stoke-on-Trent

Keep On
Sir, May I take this opportunity to congratulate you on the excellent standard of your publications? It is remarkable how you are able to keep the standard so high with minimal rescources. Keep up the good work!

D. W. LAWRENCE
Oxon

Think Nothing of It
Sir, My job with Marconi in the Orbit and attitude Control Dept. was secured by virtue of my third year University project: a computer simulation of the motion of a close Earth satellite. The project would never have got off the ground without the help of *Spaceflight's* "Satellite Digest" feature. Thanks to everyone concerned.

Y. V. LAZARI
Reading, Berks

A Small Correction
Sir, on p.282 of the June issue in my article "Lightning Research from Space" I said that a Canadian auroral camera was to be *carried* on the Galileo orbiter. In fact, Dr. C. Anger of the University of Calgary will *use* Galileo's CCD "camera" to make an aurora search on images of the unlit side of Jupiter.

JOEL POWELL
Calgary, Canada

Prelude to the Space Age
(The Rocket Societies: 1924–1940)
F. H. Winter, National Air & Space Museum, 222pp, 1983, $15.

This volume takes us back to a dim and distant past since the number of space activists alive whose work is described cannot be more than a handful.

Although the period covered is "only" 16 years, reviewing this work almost merits a book in itself. There is much about the history of pre-war rocket societies in Willy Ley's "Rockets and Space Travel", much about the BIS in "High Road to the Moon" and in many past issues of our magazines. However, this is the first time that the many pre-war amateur organizations have been put together in an historical context. The impression conveyed is wonderment at how much they achieved in the face of hostility and ridicule, with no money and with precious little practical knowledge. The author credits the true birth of Space travel to the 1920's and 1930's when these societies began and points out that none of the societies produced any long-range blueprints for a spacecraft or a space voyage *except the BIS!*

Equally significant is the comment that the late Professor Goddard had little to do with mainstream development. This was true. Goddard was a "loner". His work was conducted in great secrecy for he shunned other enthusiasts to such an extent that his work was developed almost in a backwater. Whether he was the first to invent or patent any particular development becomes academic when it is just an aside to the main stream of progress. Goddard, undoubtedly, was in a position to spearhead the development of both rocketry and space travel but he stepped to one side and it passed him by.

By comparison, both Wernher von Braun and Sergei P. Korolev, the leading German and Soviet designers respectively, were intimately involved with early space and rocket groups. The same goes for Sanger, von Pirquet, Robert Esnault-Pelterie and Kraft Ehricke, among many others. All were leading pioneers intimately concerned with such groups and played prominent parts in them.

The remark on page 108 that the CBAS became the nucleus of the post-war BIS is not strictly true. Although the CBAS assembled a membership of about 200, and produced a large audience at its meeting to approve the merger, it was really the BIS nucleus which predominated. The CBAS was numerically larger than the BIS group but relatively few CBAS members (apart from the leading lights) joined the reconstituted body. As few CBAS members became BIS members while more pre-war BIS members joined the fold, the BIS quota increased substantially. Thereafter, the Society was transfused by the entry of wholly new blood which enabled it to embark upon a major creative phase.

The author is to be congratulated for the painstaking

manner in which he has compiled and assembled a wealth of information. The research must have been enormous. Even those who recall such days will find that their memories of people, places, discussions and plans has grown dim over the years and will welcome his work.

Manned Spaceflight Log
By T. Furniss, Janes Publishing Co, 1983, 160pp, £5.95.

The enormous interest generated in the UK recently by the visit of the Space Shuttle demonstrates the hold that space travel now has for the public, particularly for the younger generation. Tim Furniss has meticulously researched the background and the inside stories to all the flights covered in the book, providing many new stories that put the extraordinary bravery of the pioneer spacemen and women into perspective.

His book gives a comprehensive log of all manned space flights plus full details of 13 almost unknown flights above 50 miles by X-15 rocket planes in which pilots qualified for astronauts wings. Each flight, both Russian and American, is described in detail in a mission-by-mission account which also includes a log of salient flight and crew details, accompanied by a selection of over 250 photographs, many published for the first time.

Particular thanks are due to Tim for mentioning both the Society and its address in his Acknowledgements.

Mars and its Satellites
J. Blunck, Exposition Press, 222pp, 1982, $10.

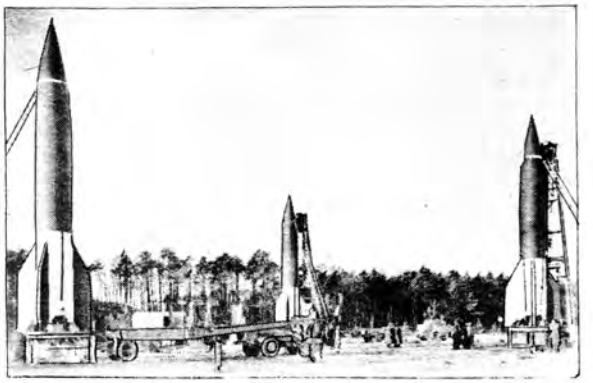
Those who wonder where those outlandish Martian names came from will find this handy guide absolutely indispensable. The first map of Mars to show recognizable features was prepared by Huygens in the mid-17th Century and, as time went by, more and more detail on the planet's surface was observed. Inevitably, there arose the question of naming these features. Some of the original old names are very romantic indeed e.g. the Hourglass Sea. In 1877, the whole thing was revised by Schiaparelli and his system has been followed ever since, though with extensive modifications in the wake of the Mars probes. The total of 304 different names used by Schiaparelli on his charts of 1877–1890 had increased to 558 in Antoniadi's map of 1930 and must now run into several thousands.

In this study the author has traced the origin and meaning of the nomenclature from the very beginning and has provided an alphabetical gazeteer based on 30 quadrangles of the planet. Not only does he indicate where the various objects are to be found but also provides background information on the origin of each name which, in some cases, seems very curious indeed.

This book is full of surprises, full of information and equally interesting for the light it throws upon the human thought-processes which threw up the names now perpetuated.

Vengeance Weapon 2 (The V-2 Guided Missile)
G. P. Kennedy, National Air & Space Museum, 87pp, $9.95.

The V-2 rocket is now so conveniently far back in time that the retelling of its story comes as something of a novelty. More than 3,000 V-2s were fired against the Allies (most against London and the Home Counties, in 1944–5) though a large number broke up during descent since they did not always arrive nose-first, but sideways. Your contributor well remembers a blinding flash as one exploded overhead in the latter part of the war, thus accounting for the loss of yet another of his nine lives. Even so, their unheralded approach was disconcerting: the first one knew



was when a major explosion occurred and reverberated throughout the district, hence the keen interest which followed the subsequent Allied bombing of both V-1 and V-2 sites, as described in this book.

The story describes how the V-2 started in the years before the war with Hitler's dream of finding a weapon which avoided the terms of the Treaty of Versaille. The story was reported extensively in early issues of *JBIS* and is now repeated in a remarkably clear and readable form for the benefit of new generations.

The V-2 did not emerge in time to enable Germany to win the war but did arrive at a crucial phase in the development of space travel for, up to that point, theory had flown far ahead of fact and there were still many arguing that a rocket could not venture into space "because there was no air to push against!"

At the end of the war the British fired several captured V-2 rockets in tests at Cuxhaven but, apart from making a truly excellent film about it, did not progress further. The Americans, on the other hand, shipped a number of vehicles to White Sands where they were launched in a series of upper atmosphere experiments.

All this is described and profusely illustrated in a book which is a joy to read.

Never at Rest: A Biography of Isaac Newton
R. S. Westfall, Cambridge University Press, 908pp, 1983, £12.50

It may come as a shock to some to reflect that Sir Isaac Newton mapped out many of theoretical parameters of space travel and, undoubtedly, would have felt quite at home in the BIS had it been founded in the 17th Century. Undoubtedly, too, he would have been the Society's first President!

This is an added reason why the authoritative biography compiled by Professor Westfall, a culmination of the work of 20 years or more, should interest so many members.

This is the second edition of his work, updated to include several interesting items about the life of this genius which emerged subsequent to the first edition. It provides a mine of information, not only as regards Newton himself but also about many of his contemporaries – mostly leading characters of the day and of the scientific world as it then existed. It is an absorbing story, made all the more interesting by a wealth of detail and the inclusion of a number of little-known illustrations.

This must be one of the best biographies ever penned.

Most of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

SPACEFLIGHT

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NOTICES OF MEETINGS

Full details on some of the meetings listed below are to be found inside the magazine.

Anniversary Dinner

50th Anniversary Dinners will be held at Society HQ on **21 & 22 October 1983**. See p. 415 of this issue for details.

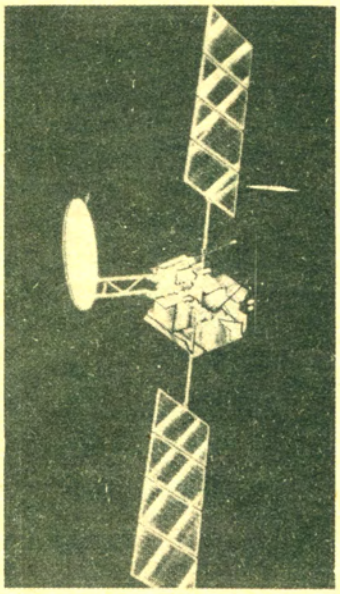
Film Shows

Two film shows on the theme of "The Depths of Space" will be held on **9 and 30 November 1983**. See p. 417 of this issue for details.

Film Show

SPACE BENEFITS

The use of space technology has brought countless benefits to Mankind. A few examples will be examined in a two-part film programme.



Part 1, on **11 January 1984**, 7.00–8.30 p.m. includes:

(a) Challenge and Promise
(b) Live *via* Early Bird
(c) Moonflight and Medicine
(d) The House that NASA Built
(e) Growing Concerns

Part 2, on **1 February 1984** 7.00–8.30 p.m., includes:

(a) Anatomy of Success
(b) Landsat: Satellite For All Seasons
(c) Hurricane Below
(d) David's World
(e) Space Navigation

Both parts will be screened in the Society's conference room, 27/29 South Lambeth Rd., London, SW8 1SZ. Members should apply in good time, enclosing a stamped addressed envelope.

One-day Symposium

Theme: **SPACE TRANSPORTATION SYSTEMS**

A one-day symposium on the above theme will be held in the Society's Conference Room on **11 April 1984**, 9.30–5.30 p.m.

Offers of papers are invited. Potential authors are requested to contact the Executive Secretary at 27/29 South Lambeth Rd., London SW8 1SZ.

Society Visit

A visit to the British Aerospace site at Stevenage in Herts. will take place on **17 April 1984**. See the inside front cover of this issue for details.

History Meeting

Theme: **BRITISH ROCKETRY DURING THE SECOND WORLD WAR**

A number of contributions will be presented at a meeting on the above topic, which has been arranged by the Society's History Sub-committee. To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **2 May 1984,** 6.30–9.00 p.m.

Admission is by ticket only. A registration fee of £1.00 is payable, which will also cover the cost of coffee. Members should apply in good time enclosing a stamped addressed envelope.

Technical Forum

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **Friday, 1 June 1984**, 6.30–9.00 p.m., and **Saturday, 2 June 1984**, 10.00 a.m. to 12 noon and 1.30–3.30 p.m.

Topic: **THE SOVIET SPACE PROGRAMME**

It is anticipated that papers will be given at the Friday evening and Saturday afternoon sessions, with some Soviet space films being shown during the Saturday morning session.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society. Members with a special interest in th Sovet space programme are invited to attend. A registration fee of £3.00 is payable. Forms are available from the Executive Secretary on request, enclosing a stamped addressed envelope.

35th IAF Congress

The 35th Congress of the International Astronautical Federation will be held in Lausanne, Switzerland on **7–13 October 1984.**

Members of the Society wishing to present papers are asked to notify Dr. L. R. Shepherd, Chairman of the BIS International Liaison Committee at Society HQ as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

Space '84

The Space '84 "weekend" will be held in Brighton on **16–18 November 1984**. Details can be found on p. 409.

LIBRARY

The Library will be open to members from 5.30–7.00 p.m. on the following dates:

9 Nov., 30 Nov. and 7 Dec. 1983

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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spaceflight

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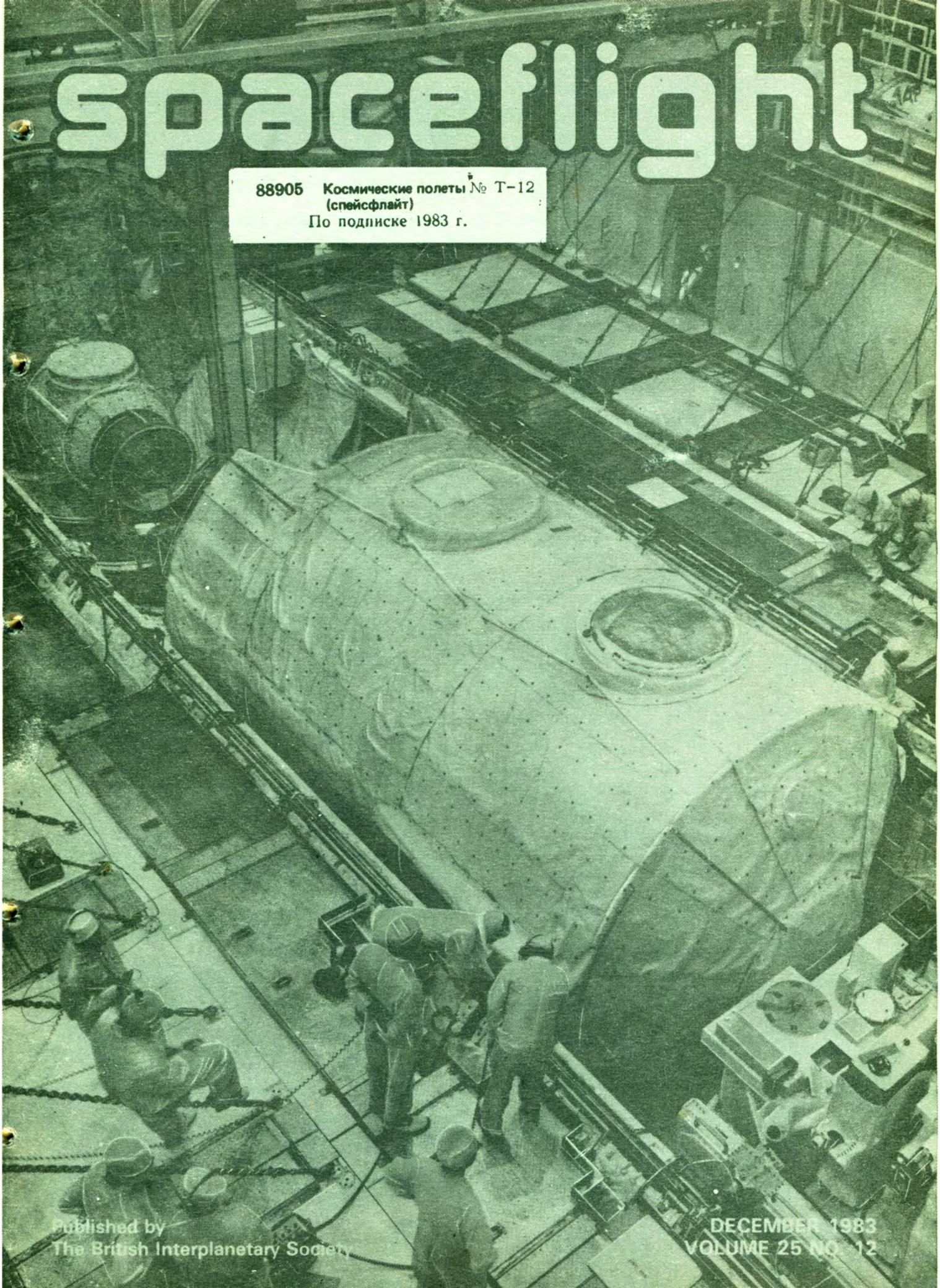

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CONTENTS

430 **The Tiros-based Asteroid Mission**
Ronald Maehl

436 **Space at JPL**
Dr. W. I. McLaughlin

439 **News from the Cape**
Gordon L. Harris

440 **What's New in the Library**

442 **Space Report**

446 **Reaching the Further Stars**
Dr. D. Froning

451 **"We Interrupt Our Programme"**
Curtis Peebles

454 **Remote Sensing in India**
R. Rao

456 **Handling the Shuttle's Boosters**
G. L. Borrowman

458 **Home Grown is Best**

459 **Satellite Radio Tracking for the Amateur**
Curtis Peebles

461 **From the Secretary's Desk**

464 **Milestones**

465 **Satellite Digest – 168**
R. D. Christy

467 **Correspondence**

468 **Book Notices**

BIS MEMBERSHIP DRIVE

For some years the Council has followed the policy of keeping subscription rates steady and concentrating instead on promoting membership. This has paid off handsomely with the loyalty, interest and goodwill of members demonstrated to us repeatedly. Our subscription rates, already quite low, will stay the same for 1984. Most other organizations have put up their rates frequently over the years but we have not – with the result that our fees are now at the lower end of the scales charged by learned societies.

But we need funds to pay for membership promotion so financial help has a high priority. One excellent way of helping the Society is to acquire copies of our three books. They were all prepared voluntarily to ensure that members had access to some excellent astronautical material at extremely reasonable prices, besides providing funds to help our Society. Titles are: *Daedalus Report* (£7.00/$12.00), *High Road to the Moon* (£6.00/$10.00) and *The Eagle Has Wings* (£7.00/$12.00). They are all good value for money.

To go further we have to make a major effort to increase membership. There is so much that one can do to encourage others to join, from displaying Society material at work to mentioning the BIS in publications and elsewhere. Authors (and there are quite a few in the Society) who mention the BIS in articles, letters for publication and books do us a great service, especially if the relevant address is provided. Another excellent example is the Daedalus project. The publicity generated by this forward-looking study generated worldwide enquiries and many new members who would not have known of our existence otherwise. Members who appear on radio and TV are also very well placed to refer to the Society's work.

Every member can do something by introducing *at least one new member*. We will be more than happy to send specimen magazines and our new simplified application form direct to anyone nominated, or even a bulk quantity to members who can put them to good use.

Growth in membership is now our major aim. Some members may be able to exert considerable influence by reason of their status, connections, seniority, position, etc. To them, particularly, we direct a special appeal.

If you are able to influence the technical intake into our Society please do so. Our Society's future standing and its contributions to astronautics depend very much on your support.

COVER

The Spacelab pressurised module and its attached experiment pallet (seen at bottom right) are lowered into the cargo bay of Shuttle Orbiter *Columbia* at the Kennedy Space Center in Florida. Note the transfer tunnel from the Shuttle crew compartment at top left, and the handrails on Spacelab in case an astronaut had to perform a spacewalk.

NASA

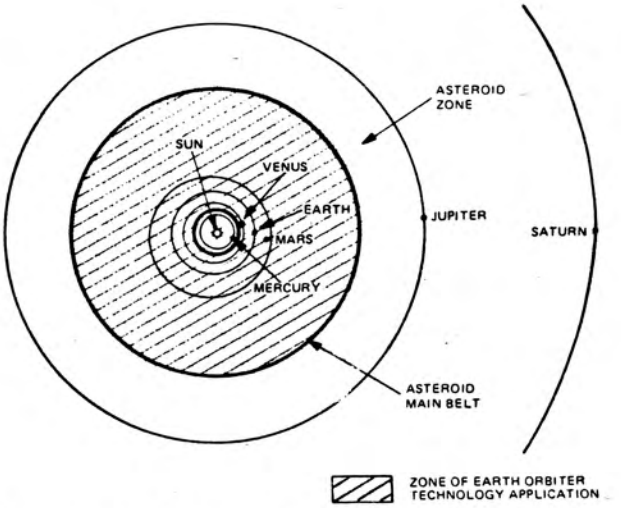
ISSN 0038-6340

THE TIROS-BASED ASTEROID MISSION

By Ronald Maehl*

Since asteroids could provide a unique sample of material that may hold significant clues to the way the Solar System was formed and has evolved, they are prime candidates for exploration. Very little is known about asteroids other than that they exhibit diverse properties and are found in a wide range of orbits, primarily situated between Mars and Jupiter (the main belt) but with a significant number having perihelion near and even inside the Earth's orbit.

To fully understand the asteroids and their implications to Solar System physics, an orderly study of several different types, *via* spacecraft in asteroid orbits, is required. A logical first step in this progression is the study of one or more Earth-approaching asteroids. This approach will allow cost-effective first missions by the use of Earth-orbiter spacecraft technology for limited missions that will, aside from their own scientific merit, set the stage for multiple-asteroid-rendezvous missions with main belt asteroids.



The volume in which adapted Earth-orbiting satellites can be used for deep space missions. Beyond, thermal and/or power problems would need major redesign work.

Introduction

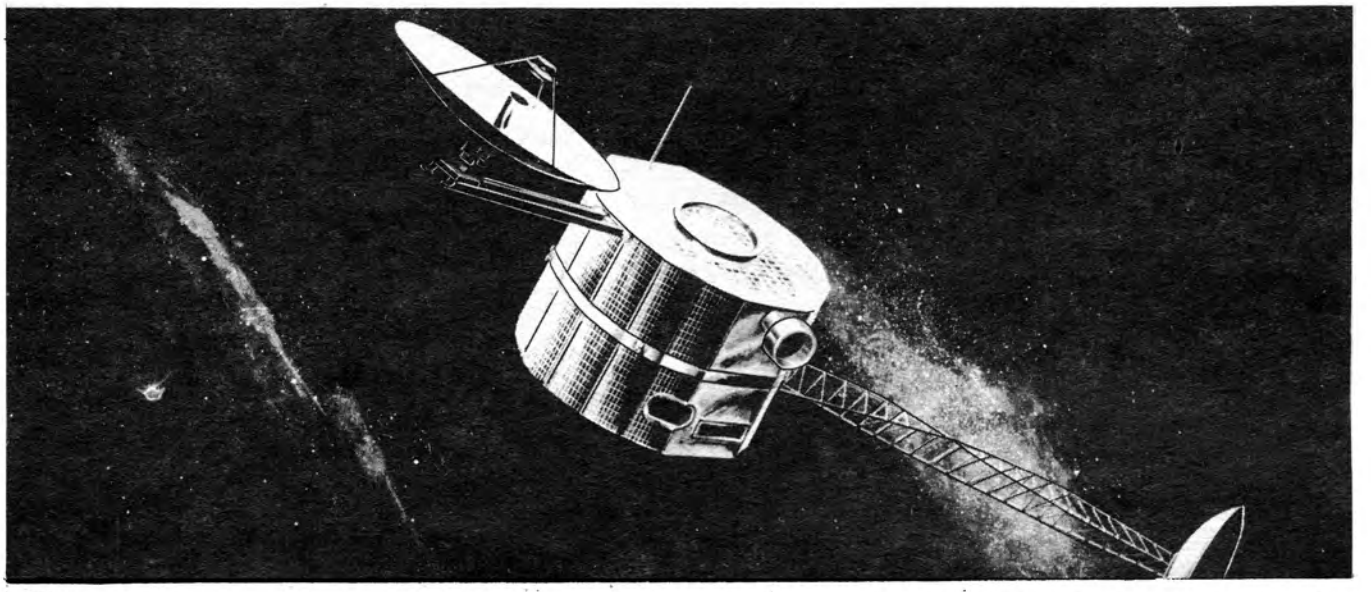
Very few missions have been more intriguing and enlightening than those to deep space. First, there were the preliminary lunar missions, precursors to the Apollo programme, followed by preliminary fly-by probes to Mars, Venus and Mercury. Based on the technology and scientific return from these missions, we expanded our study of the inner planets to include a Mars landing and sample analysis, sophisticated multi-spacecraft missions to Venus, and then fly-by missions to the outer planets – Jupiter and Saturn.

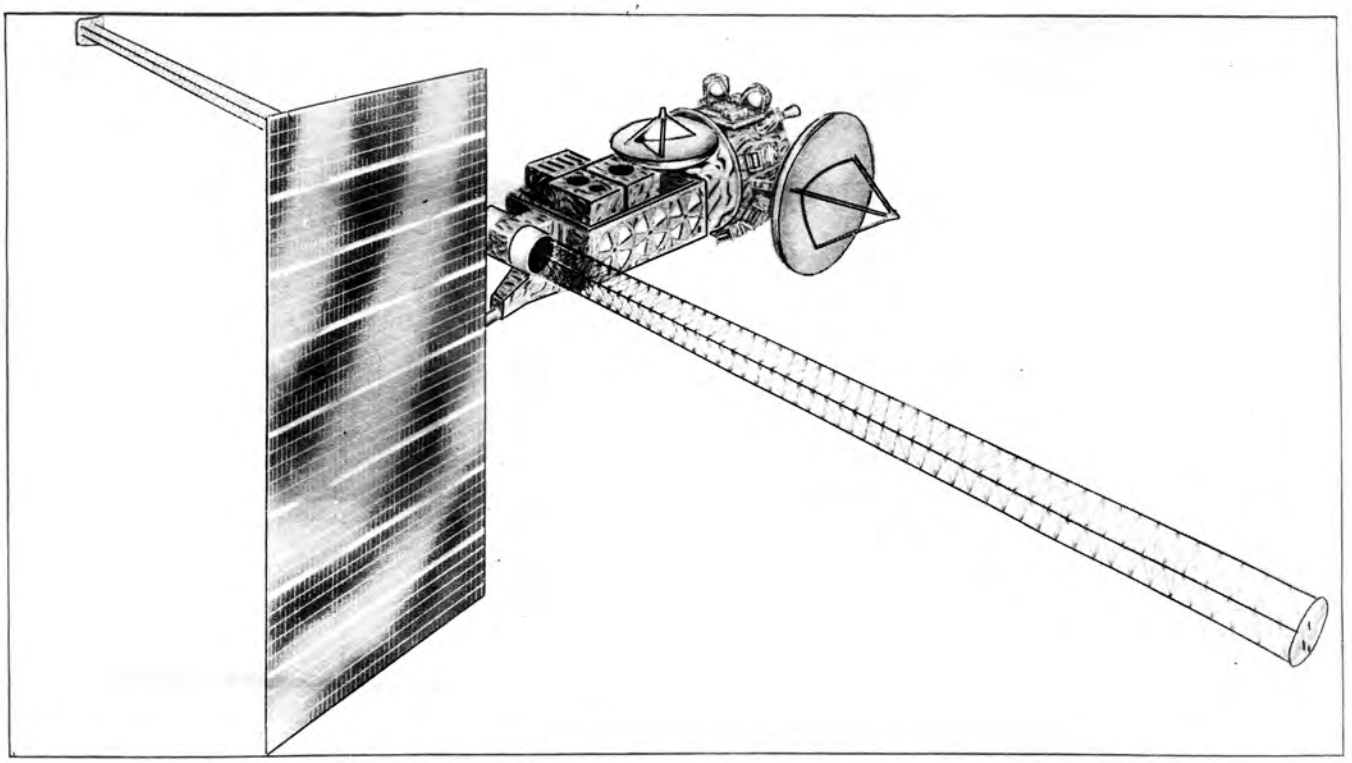
Outer-planet fly-bys, first done by Pioneers 10 and 11, and subsequently by the more sophisticated Voyager 1 and 2 spacecraft, provided spectacular data that have greatly expanded our understanding of these giants of the Solar System. More importantly, when taken together with the body of knowledge gained from the more detailed data available from the inner planets, the outer-planet fly-bys provided us with a far more sophisticated view not only of our Solar System but also of our Earth as a planet. These data provided us with significant clues to the evolution and, perhaps, the future of our own planet's atmosphere and topology. For example, scientists can relate such seemingly varied topics as plate tectonics (continental drift), evolution of the atmosphere, and development of life on the Earth by way of a complex series of hypotheses, still very preliminary, which involve data gained from these planetary missions.

The first look at Uranus, and possibly Neptune, will

*Manager, Market Development, RCA Astro-Electronics, New Jersey, USA. *This article first appeared in "RCA Engineer", March/April 1983.*

A second option for a deep space mission could be based on the Dynamics Explorer satellites, now in orbit probing high-energy events near the Earth.





The Tiros craft converted for asteroid work. Note the addition of a large solar panel, the dishes and the magnetometer boom.

be provided by Voyager later in this decade, extending still further man's presence in the Solar System. In addition, the Galileo orbiter/probe mission, also later in this decade, will provide our first in-depth study of Jupiter. For the first time, a probe will sample the atmosphere of this, our system's largest planet. In the same time frame, the Venus Mapper will make detailed maps of the surface of Venus. A synthetic aperture radar system aboard the spacecraft will, for the first time, sufficiently resolve surface details of the cloud-shrouded planet to allow an in-depth geological comparison with our planet.

Given the current state of our exploration of the Solar System, the next set of targets are quite readily chosen. They are the minor bodies – asteroids and comets.

Asteroid Exploration

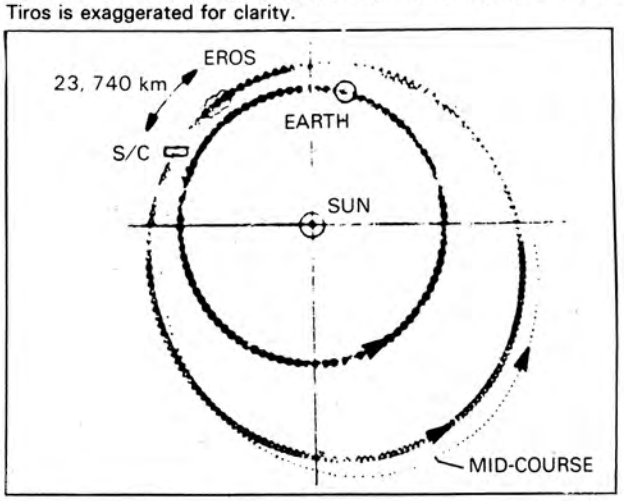
Asteroids and comets are extremely important to our understanding of the evolution of the Solar System. They may provide unique samples of the primordial material from which the Solar System evolved, uncomplicated by the geological evolution that has taken place on the inner planets.

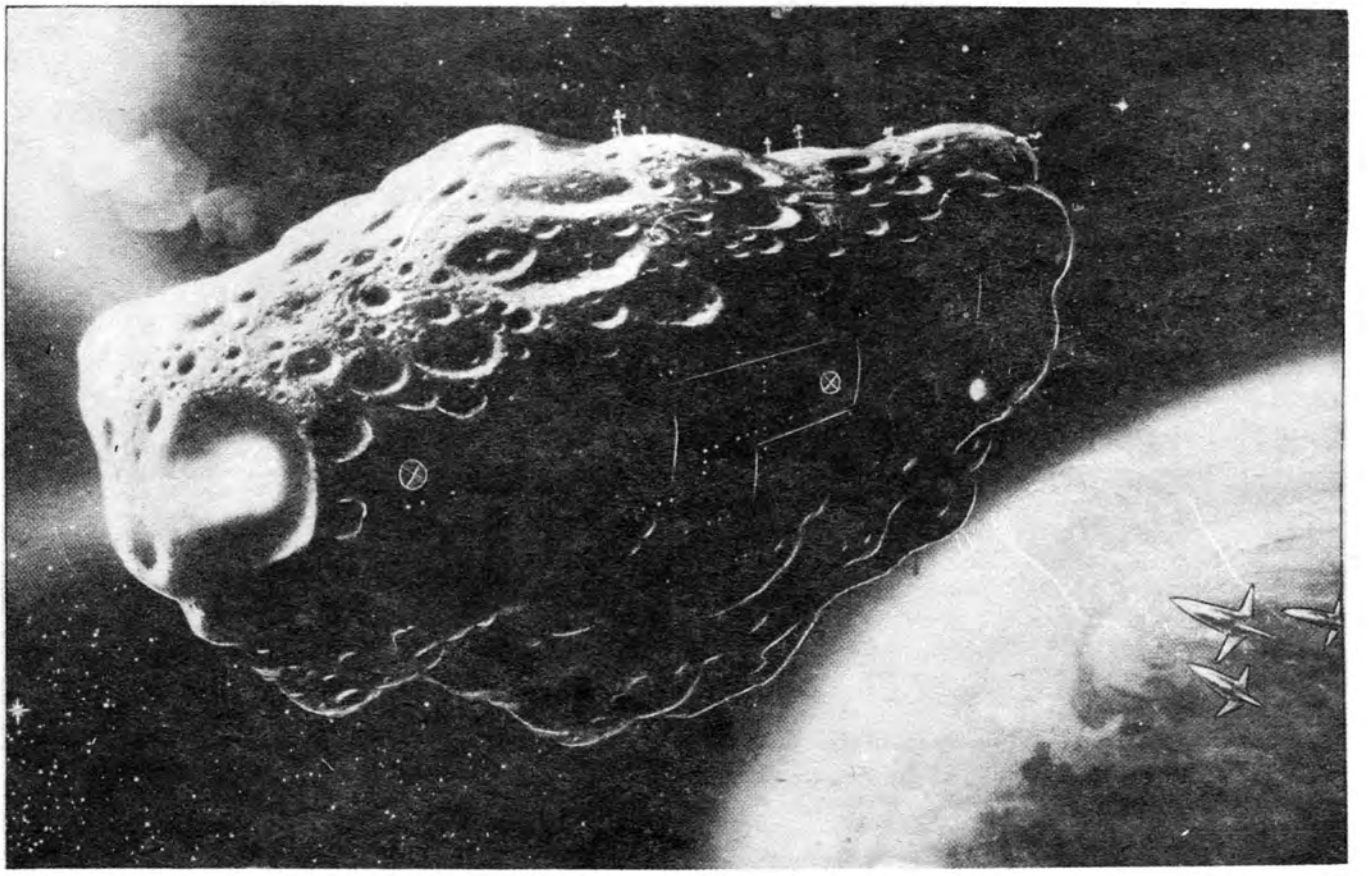
Asteroids, aside from being key to our understanding of the Solar System, may also be important for other reasons. Because they are suitable for manned missions, they could be tapped for their mineral wealth, whether it be exotic materials that may be in short supply on earth or, more likely, common materials for use in large-scale space structures.

This last option is potentially feasible because many asteroids are in orbits that could provide material (either processed or for processing) to geosynchronous orbit with far less energy required than would be necessary to bring the same mass from Earth. This possibility leads to speculation that, for example, aluminium-smelting operations on a manned asteroid base or an asteroid mine could provide raw material to a manufacturing facility in Earth orbit. A manned asteroid base could also provide for a variety of other space research and manufacturing operations. There is almost no end to speculation as to potential uses of an asteroid.

Currently, the simple fact remains that, before any of these possibilities can even be seriously considered, we must significanty understand the physical and chemical properties of asteroids, and this is precisely what would be done with a preliminary scientific spacecraft mission to such a body. As of today, the only data available are from ground-based observation. These data allow us to make some crude classification (by spectral type), to calculate spin rate, and, with some assumptions, to estimate the size distribution of the asteroids. But these observations are inadequate for anything more than the selection of a target for precursor missions, required as preliminaries to exploitation of the asteroids. Further, because asteroids exhibit such diverse properties, multiple rendezvous missions to many different types of asteroids will be necessary.

Trajectory for an Eros rendezvous; several launch windows are available (see the energy diagram). The separation of Eros and Tiros is exaggerated for clarity.





Further in the future: an "asteroid ark" meets a reception committee on arrival at its destination planet. (c) David Hardy, from *The New Challenge of the Stars*, 1978.

Several scientific working groups have addressed the question of what sample of asteroids would provide an adequate, general understanding of their nature. In general, recommendations include several sizes of asteroids and a wide range of orbital parameters (between 1 and 5 astronomical units) including one group, the near-Earth asteroids. These could be studied, at low cost, using modified Earth-orbiter spacecraft technology (the RCA Tiros spacecraft) and existing launch vehicles.

Low Cost Options

The concept of low-cost planetary spacecraft has been evolving at RCA since 1980. In 1981 and 1982 NASA funded studies to RCA and others through both the Jet Propulsion Laboratory and Ames Research Center for low-cost Mars missions. The concept of using a modified Tiros spacecraft for an asteroid-rendezvous mission was first developed under an RCA Independent Research and Development (IR&D) project, and later development was funded by the Jet Propulsion Laboratory through a systems-study contract. Initial work done at RCA established the limits of applicability of Earth-orbiter spacecraft to deep-space missions. The established boundaries extend from Venus to the asteroid belt. Any closer to the Sun than Venus (for example, Mercury) and the thermal constraints are so significant that systems designed for Earth application are totally inadequate. Going away from the Sun, Mars is an ideal candidate for the application of Earth-orbiter technology; in fact, the environment the spacecraft would see in orbit around Mars is surprisingly close to that of Earth. Going out farther, some designs may be applied to main belt asteroid missions. The major limitation would be the power that could be derived from the solar array. However, at Jupiter and beyond, it can be clearly demonstrated that Earth-orbiter technology does not apply. At these distances, radiothermal generators must replace solar arrays as the source of power, and the extremely cold temperatures preclude use of Earth-orbiter thermal design. In addition, the environment near Jupiter and the planets beyond is characterized by intense radiation hazards that exceed nominal design limits of most spacecraft.

With the range of applicability of Earth technology established, clearly a wide range of missions of scientific interest can be accomplished cost effectively, with no scientific compromise, by application of Earth-orbiter technology. Near-Earth asteroid-rendezvous missions are one of the most exciting prospects. To fully appreciate the rather astonishing conclusion that Tiros (a spacecraft designed to make meteorological observations from a low-Earth circular polar orbit), can fully support a mission as exotic as an asteroid rendezvous, it becomes necessary to understand in more detail the rationale (and therefore the instrument complement) behind the asteroid mission. To do this, let us momentarily digress to answer some questions about what exactly we hope to learn in the first mission.

Table 1. Comparison of actual Tiros-N and proposed Tiros-N/Anteros primary sensors.

Parameter	Asteroid Imager	Tiros Radiometer	Anteros Spectrometer	Tiros IR Sounder
Mass (kg)	28.0	30.4	18.0	33.1
Power (W)	25	30	16	22
Dimensions (cm)	30X24X88	51X30X65	66X47X81	51X30X65
Data rate (kbps)	806.4	660.0	11.5	2.88

Near-Earth Asteroids

The first obvious questions are: Where do the asteroids come from? Are they remnants of an exploded planet or perhaps a planet that never quite formed? Did they evolve in their present form because of the influence of Jupiter? Why are they mostly concentrated between Mars and Jupiter?

We know that most asteroids fall in a region called the "main belt" (between Mars and Jupiter). However, we also know that asteroids are not constrained to lie in that belt. Hundreds or perhaps thousands penetrate deep into the inner Solar System, extending into, and even across, the orbit of Earth. This set of asteroids, Earth-approaching and Earth-crossing, are taken together as "near-Earth" asteroids. To fully understand the nature of asteroids and their implication to the development and evolution of the Solar System, it is important to study both main belt and near-Earth asteroids and to understand their relationship. Because we need to study both types, and because near-Earth asteroids are by far more easily accessible than main belt asteroids, it is logical to select them as the target for the first spacecraft mission.

Given this selection, the questions the first mission should address are readily defined. Specifically, where do the near-Earth asteroids come from? Are they merely asteroids from the inner edge of the main belt whose orbits were perturbed, perhaps by a close approach to Mars, that sent them on orbits into the inner solar system? Are they extinct nuclei of short-period comets, or are they in any way related to comets? Perhaps they have nothing to do with main belt asteroids or comets. If so, where do they come from?

The next question is: What is the relationship of Earth-approaching asteroids to meteorites and their classification? Meteorites fall into a highly structured classification scheme, and an understanding of the relationship between the asteroids and this classification scheme is potentially of great value. This knowledge would help us to understand asteroids, and would also provide a better understanding of the geologic and/or cosmogenic context in which the vast amount of meteorite data that exists should be placed. This can also be said of the lunar data provided by Apollo. In addition to these major questions, there are many other second-order questions related to the space environment that the study of asteroids could answer.

First Mission Objectives

To allow us to address these questions, the first asteroid mission will be required to (1) determine chemical and mineralogical composition, (2) observe surface morphology, (3) determine bulk density and density distribution, and (4) determine magnetic properties. Definition of a baseline instrument complement that could be used to address these objectives was completed at JPL and supplied to RCA. Instruments included were a gamma-ray spectrometer, an X-ray spectrometer, a multi-spectral infrared mapper, an altimeter, an optical (CCD) imager, and a magnetometer.

Table 1 shows a comparison between the existing Tiros instrumentation and the asteroid-mission instrumentation. This comparison clearly shows that the spacecraft requirements to support both sets of instruments are similar. Imagers and sounders that Tiros normally carries are nadir-pointing devices that must be held steady and properly pointed. The same is true of the imager, infrared mapper, altimeter, and spectrometers on the asteroid mission. One significant difference is that total weight and mounting area requirements are significantly less than those of Tiros, allowing for simplification of the basic spacecraft. In addition, the power, thermal, command and control, and data systems of Tiros can be applied to this mission with little or no modification. The communications system, of course, requires extensive modification because, as is the case in any deep space mission, the distances from the Earth to the spacecraft are exceedingly large. This necessitates a large high-gain antenna. The attitude-control system also needs some modification due to the required use of a star reference for navigation guidance. Tracking, command and data acquisition will be carried out *via* the Deep Space Network.

STS Launch Vehicle

One of the key elements of this mission is the ability to use an existing launch vehicle, thereby avoiding the programmatic and cost problems that arise when launch vehicle development is required in parallel with spacecraft development. Accordingly, it was decided at the outset of the study that the selected target asteroid must fall in a category accessible by existing vehicles. The launch system chosen was the Space Transportation System (STS) with the two-stage Inertial Upper Stage (IUS).

Mission Scenario

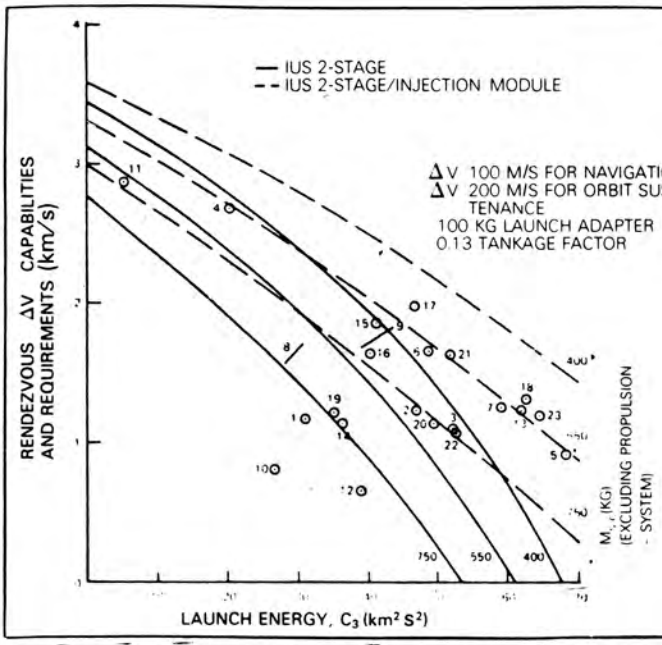
If we take the known performance of the STS/IUS combination, the mass of the spacecraft, and the orbit of the target asteroid, we can determine whether we can provide the energy to make the mission feasible. In essence, we calculate if it is possible to achieve the same orbit about the Sun as that of the target asteroid. In general, to rendezvous with the asteroid, a five-phase mission is involved.

First, the STS lifts off and goes to a standard STS parking orbit with an acceptable inclination as determined by the orbit of the target asteroid. Second, the IUS/spacecraft combination is separated from the STS, and, after achieving proper inertial reference and a safe separation distance from the STS, the IUS fires and injects the spacecraft into the proper heliocentric transfer orbit. Remnants of the IUS and separation adapter are then jettisoned, the array is partially deployed, the cruise phase configuration is assumed, and the second phase of the mission begins. This phase of the mission will last between 3 and 12 months (depending on the target) and involves a cruise coast around the Sun.

During this mission phase, the spacecraft and instruments are essentially dormant; periodic checkouts, health monitoring, and an occasional midcourse correction are the only planned activities. While in this phase,

Discovery of an asteroid. Asteroid 1982TA was discovered with the 1.2 m Schmidt telescope at the Palomar Observatory, showing up as a streak on the photographic plate.

World Space Foundation


— IUS 2-STAGE
– – IUS 2-STAGE/INJECTION MODULE
ΔV 100 M/S FOR NAVIGATION
ΔV 200 M/S FOR ORBIT SUSTENANCE
100 KG LAUNCH ADAPTER
0.13 TANKAGE FACTOR
ACCOUNTED FOR
RENDEZVOUS ΔV CAPABILITIES AND REQUIREMENTS (km/s)
LAUNCH ENERGY, C_3 (km² S²)
M_p (KG) (EXCLUDING PROPULSION SYSTEM)

	NAME	LAUNCH
1	3673 1980 PA	10.30.88
2	2061 ANZA	10.07.88
3	3643 1972 RB	08.25.88
4	3684 1980 YS	02.12.89
5	887 ALINDA	01.04.90
6	1627 IVAR	07.24.90
7	3688 1979 QB	09.15.90
8	1943 ANTEROS	05.27.87-06.06.87
9	1943 ANTEROS	05.22.90
10	1982 DB	01.09.89
11	1982 DB	02.05.88
12	3636 1980 AA	01.14.88
13	3669 1979 VA	09.25.88
14	3687 1981 CW	01.14.89
15	3650 1977 VA	10.16.89
16	433 EROS	01.25.89
17	2368 BELTROVATA	08.04.89
18	3641 6344 PL	11.18.89
19	1943 ANTEROS	05.22.90
20	3636 1980 AA	01.14.90
21	3673 1980 AA	10.19.90
22	1627 IVAR	08.01.90
23	2061 ANZA	09.29.90

This plot shows launch energy (C_3) plotted against total velocity increment (ΔV) achievable for the current design. Any asteroid that falls under this curve is a viable target.

detailed tracking of the spacecraft and the asteroid are ongoing, and midcourse manoeuvres are derived from this detailed tracking data. The target window for the spacecraft is an imaginary circle, centered on the asteroid, with a radius of about 6000 km.

As the spacecraft approaches the asteroid, the third phase of the mission begins. This is the crucial phase in which the onboard propulsion system (a large hydrazine system in the current system design concept) is used for a major velocity adjustment (on the order of 1 to 2 km/s) that takes the spacecraft from the transfer orbit to the asteroid orbit. At this point, the spacecraft is flying along with the asteroid, in the same orbit, but far enough away to be unaffected by its gravitational pull. At this point, the asteroid will appear, to the spacecraft, as the brightest object in the sky, somewhat like a full Moon appears on Earth, and therefore, will be detected easily by the on-board instruments. All instruments will be brought on line, checked out and will begin operation. Images that start coming back from the asteroid will provide not only scientific data but also a critical navigational tool for the fourth phase, the approach to the asteroid.

During this phase, the spacecraft is given a small push, by its propulsion system, in the direction of the asteroid. Over a period of several days, it slowly approaches, imaging the target as it goes. Onboard sensors carefully monitor any perturbations to its trajectory as it enters the asteroid's gravitational sphere of influence.

When the sphere of influence of the asteroid is reached, the fifth mission phase begins. At this point, several mission options are available. These include (1) sequential drift arcs, that is, repeated hyperbolic passes past the asteroid from long distances: (2) interrupted free fall, that is, stopping the spacecraft, letting it fall towards the asteroid, and then interrupting the free fall before impact; (3) stationkeeping, that is, holding a fixed orbital position over the asteroid; and (4) orbiting.

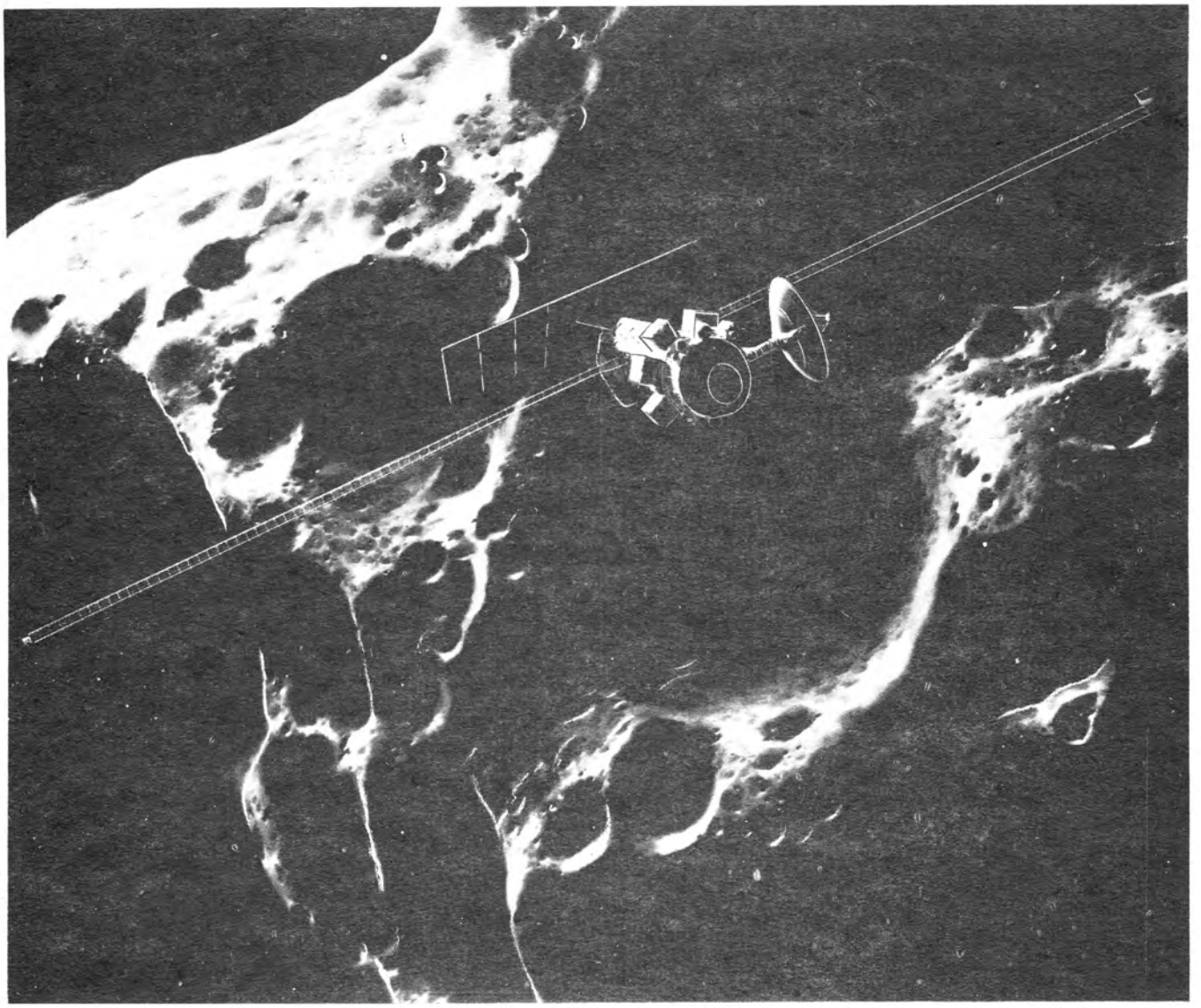
The reason so many options are available and, for the most part energetically feasible, is that asteroids are small, and their gravitational attraction is very weak. For example, on a typical asteroid a few kilometres in diameter, the escape velocity is so low that a man running across the surface would fly off into space and escape the asteroid's gravitational pull. Another consequence of this weak gravitational attraction is that altitudes and velocities for our orbiting spacecraft are on the order of 10 km and less than 1 m/s, respectively, far different from what we are accustomed to dealing with.

Calculations have been done on the consequences of these various options, and the current mission scenario involves three of the four. Stationkeeping has been eliminated because, even given the weak gravitational attraction of the asteroid, fuel requirements are excessive at the low altitudes we would like to achieve.

In the current baseline, near the end of phase four, we would target the spacecraft and adjust its velocity so the first pass near the asteroid would result in an unbound hyperbolic trajectory (the sequential drift arc). We would then stop the spacecraft, reverse its direction, and fly a series of such manoeuvres at an ever-decreasing, closest-approach distance. After this series of manoeuvres, we would have a fairly detailed map of the surface and would be able to safely define an optimum orbit into which we would then insert the spacecraft. From this orbit, detailed magnetic field and altimetry observations would be done, surface maps would be improved, and the X-ray and gamma-ray survey would be done.

After accomplishing detailed orbital coverage, we would "stop" the spacecraft and do a series of interrupted free-fall manoeuvres to image the asteroid as closely as possible. The entire duration of the fifth mission phase would be between 3 and 12 months. At the end of the mission, we would most likely attempt as soft a landing (in reality a quasi-controlled crash) on the asteroid as possible. For this first mission, such a manoeuvre would not be mission critical and should, at most, be construed as an engineering test for the next-generation mission.

Up to now we have considered target asteroids only in a generic sense. It is possible to quantize the constraints due to spacecraft size, IUS performance, and orbit-injection-velocity change requirements and



A Tiros-type craft visits an asteroid in this conceptual painting by Paul Hudson.

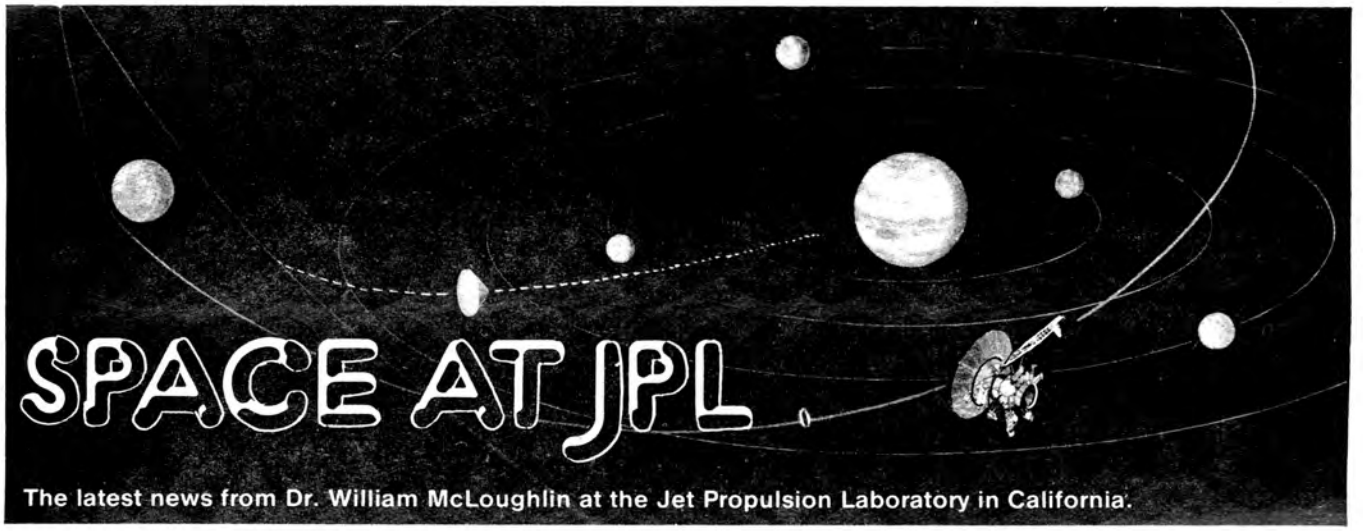
relate this to the accessibility of specific asteroids. In the energy diagram C_3 is plotted (in essence, the launch energy achievable from the IUS) against the total velocity change requirements, post injection. Several asteroids are plotted on this graph at the point where the C_3 and ΔV would allow an entry to their orbit (and a launch window for rendezvous). The line of the graph shows what is achievable, using an all-hydrazine propulsion system, for a 500 kg dry spacecraft – roughly the Tiros asteroid spacecraft mass. Any asteroid that falls below this line is, therefore, a viable target.

One important consequence of viewing the problem this way is that it allows the project to begin even before the target is selected. So long as the ultimate target asteroid falls below this line, it is a feasible mission option. The working baselines for the study were the asteroids Anteros and Eros, both shown on the graph. New asteroids are being discovered periodically, and the list is expanding. The asteroid that is currently the easiest to get to, 1982 DB, was only recently discovered (and was a relatively near miss in its most recent pass by the Earth).

Conclusion

In summary, the Tiros/asteroid spacecraft mission has significance in two very important respects. First, as the maiden mission to a minor body, it will provide our first look at a very important class of bodies in the Solar System and will therefore provide the opportunity for basic discoveries in much the same way Voyager provided information about the outer planets. This mission will also serve as a precursor, providing critical data required to plan more extensive asteroid missions, perhaps leading to manned missions followed by manned bases to exploit the resources of the asteroids. Second, of equal importance, this mission could be the first of a series of low-cost, deep-space missions that would permit us, consistent with the NASA budget for planetary programmes, to significantly expand the number of missions flown. This expansion will allow us to increase our knowledge of the Solar System *via* optimum use of the Shuttle's capability.

Other missions currently being considered for this series include several Mars missions that include climatology, geochemistry and aeronomy, and a lunar polar orbiter that would survey the polar region of the Moon and ascertain whether the Moon can be a source of raw materials to be used for manufacturing in space. In fact, the same Tiros spacecraft described here is also a candidate for several of these missions, opening the possibility of a spacecraft series that would further enhance the cost-effective exploration of the Solar System and our understanding of the implications for our own planet.



SPACE AT JPL

The latest news from Dr. William McLoughlin at the Jet Propulsion Laboratory in California.

MARS ORBITER

The investigations of Mars by Viking and Mariner missions have resulted in a quantum leap in our knowledge of the fourth planet in the last two decades. These experiences now allow us to use proven techniques in spacecraft and mission design to plan low-cost missions to Mars which focus upon open questions of scientific importance.

The approach of low-cost, focused-science missions has been recommended by the Solar System Exploration Committee of NASA, and the Mars Geoscience Climatology Orbiter (MGCO) represents one of four core missions designed to implement this recommendation (see the September-October "Space at JPL").

Though it is not presently funded as a project, studies are underway at JPL to define the objectives and characteristics of MGCO. Some scientific questions to be addressed include: the mineralogical composition of the planet's surface and its relation to geological processes; the possible transport of water between Martian hemispheres and better understanding of the polar caps; the gravitational figure and planetary magnetic field; circulation of the atmosphere and causes of dust storms. The MGCO scientific payload to investigate these questions has not been defined in detail but may consist of about eight instruments, such as gamma ray and infrared spectrometers for mineralogy and chemistry, a radar altimeter, a magnetometer, and ultraviolet instrumentation for atmospheric studies.

The spacecraft would be a relatively inexpensive Earth-orbiting type obtained from private industry with minimum modifications to make it serviceable for interplanetary usage: the first in a series of "Planetary Observers" for application to the exploration of the inner Solar System (the outer Solar System would be explored by JPL's proposed Mariner Mark II). The planned launch system is the Shuttle with a suitable upper stage. Depending on project approval, launch could occur as early as the August 1990 Mars opportunity.

The basic mapping of Mars would be achieved from a polar orbit at an altitude of 350 km and would extend over one Martian year (687 Earth days), with a possibility of an extended mission for one additional Martian year. After the completion of the scientific portion of the mission, the orbital altitude would be raised so as to avoid early entry into the atmosphere and violation of planetary-quarantine regulations for Mars.

A major cost-reduction effort in mission operations will be undertaken with minimal staffing of the project after launch and maximal participation of scientists (principal investigators and their associates) in the design of simple, repetitive sequences.

Clearly, the day of the global survey is here with Landsat (a Goddard project) and IRAS (Infrared Astronomical Satellite) now mapping Earth and sky, and proposed survey missions, VRM (Venus Radar Mapper), EUVE (Extreme Ultraviolet Explorer), and TOPEX (Ocean Topography Experiment) under intensive examination at JPL.

TETHERED SATELLITE SYSTEMS

This month's advanced-concept review focuses upon a technology for planetary exploration rather than a specific mission. The technology is that of a tethered satellite system; if two satellites are tied together by a wire (tether) they can orbit a planet in a stable configuration wherein both satellites are travelling at different altitudes. The combined system moves at an orbital speed appropriate for the altitude of its centre of mass, located somewhere between the tethered masses along the wire. Thus, the higher satellite travels at a speed faster than normal for its altitude, while the lower satellite travels at a slower than normal speed.

This surprising result was known as long ago as 1895 by Tsiolkovsky and was the subject of experimentation on the Gemini 6 and 7 missions. However, the use of tethers in the design of space missions was largely neglected until 1974 when Dr. Giuseppe Colombo proposed tethering a small mass as far as 100 km below the Shuttle in order to sense the environment at an altitude lower than is normally accessible by satellites of the Earth. This proposal has matured into a cooperative programme between Italy and the US: the Tethered Satellite System (TSS) managed by NASA's Marshall Space Flight Center. A first flight is planned for 1987. Perhaps as surprising as the concept of tethering over great distances is the small diameter of the connecting wire: 1 to 2 mm in the case of TSS.

A review of the anticipated uses of tethered systems in Earth orbit appeared in the April 1983 issue of *Astronautics and Aeronautics*. In this piece Ivan Bekey describes numerous applications including interactions between the Shuttle and NASA's proposed Space Station. A Shuttle could rendezvous and dock with the station and, when ready to depart, could be lowered by tether below the station. As a result of tethering, the station would be travelling faster than normal and the Shuttle slower; hence the station would rise slightly when the tether was released and at the same time the Shuttle would dip lower. This situation would be advantageous for both: drag compensation for the station and an assist on the return to Earth for Shuttle.

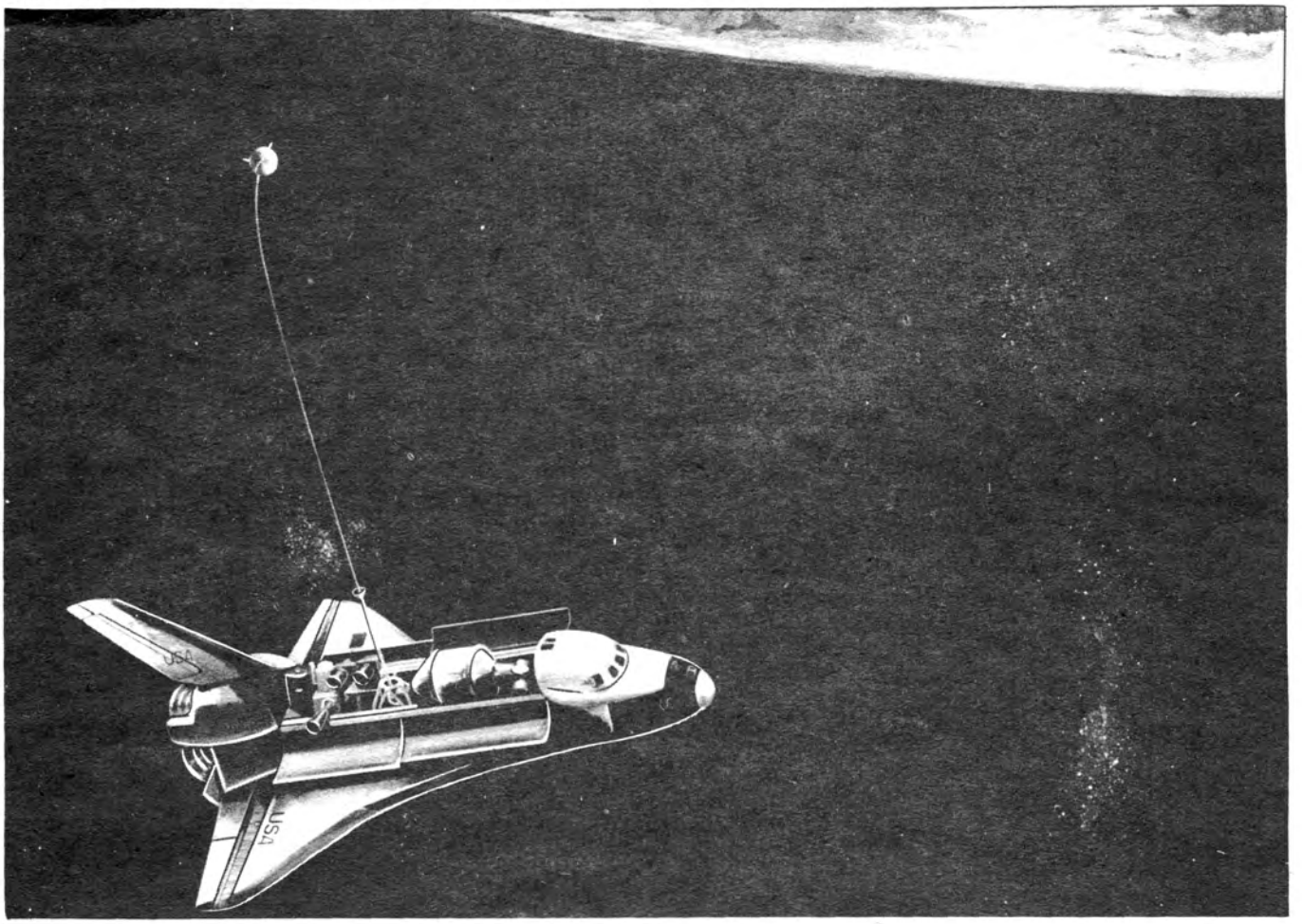
Applications of the tethering concept to planetary exploration have begun to be examined by the Jet Propulsion Laboratory. Dr. Charles Tang is analyzing the detailed dynamics of tethered systems using computer-algebra techniques (see "Space at JPL" in the April issue). The behaviour of unmanned, tethered systems must be well understood since they would be untended

The logo illustrates the tethering of a satellite from the Shuttle in the planned TSS cooperative project between the United States and Italy.

NASA

for long periods of time. A second effort, led by Dr. Paul Penzo of JPL, is looking at specific planetary uses for tethered systems. This effort is part of a larger Tether Applications Task Group staffed by several NASA centres and headed by George von Tiesenhausen of the Marshall Space Flight Center.

A highly regarded mission option would be to tether two synthetic aperture radars (SAR) together in order to conduct interferometric studies of a planetary surface. Another application would be to lower a scoop from



an orbiter to gather atmospheric or even surface material. In a similar fashion, a "sky hook" could be lowered to aid in recapturing a sample-return probe from a planetary surface. Tethers could also serve as aerocapture mechanisms by deploying a tethered drag device from a spacecraft into an atmosphere, eliminating the need to aerodynamically shape and thermodynamically shield the mother ship. This is sometimes referred to as a "space anchor." A mass lowered close to a planetary surface would not only permit atmospheric studies but would be of value in sensing the planet's gravity field at close range.

If the planet has a strong magnetic field, such as Jupiter, electric power could be generated with a conducting tether as it cut the planetary magnetic-field lines. Reversing this process by passing an electric current through the tether would produce a force on the spacecraft, augmenting its velocity without the use of propellant.

IRAS AND VEGA

The discovery by the Infrared Astronomical Satellite (IRAS) of particles circling the first-magnitude star Vega is a significant milestone in an area common to stellar and planetary astronomy. In infrared astronomy it is not uncommon to find stars that are accompanied by clouds of dust and gas. However, such stars are usually quite young, having recently formed out of the interstellar medium, and the surrounding material is just left over from the stellar-birth process. Vega is approximately a 1000 million years old (the Sun is about 4.5 times that) and so cannot be classified as a young star. The significance of finding material about a star of this age is that the material must be composed of particles larger than mere gas or dust; in the course of a 1000 million years very small particles would have been expelled from the system by stellar radiation pressure or drawn into Vega by an effect known as Poynting-Robertson drag. IRAS does not have the resolving power to determine if, among these particles, any are of planetary size.

Vega is one of the brightest stars in the sky. Its name is of Arabic origin, and it figured prominently in Babylonian, Chinese, Greek and Roman astronomy. About 14,000 years ago Vega was the pole star, a position which it will occupy again in 12,000 years due to the precession of the equinoxes which results from the gravitational torques of the Sun, Moon and planets.

In modern astronomy Vega has frequently been used as an object for calibrating astronomical instruments since its light is very constant. It was exactly this use by IRAS which resulted the discovery of the circumstellar material by Drs. George Aumann of JPL and Fred Gillett of the Kitt Peak National Observatory. Aumann and Gillett noticed that an extensive region around Vega was bright in the infrared and, upon further observation and theoretical calculations, announced the existence of a particulate region stretching approximately 80 AU from the star (an AU or "astronomical unit" is the distance from Earth to Sun: about 150 million km). On the average, Pluto is about 40 AU from our Sun.

Aumann and Gillett are both members of the 18-man Science Team of IRAS, nine from the US and nine from The Netherlands and the UK, and have long been associated with the project. Since the launch of the satellite in January they have worked at the IRAS Control Centre at the Rutherford and Appleton Laboratory in Chilton, England. Prior to launch, both made extensive contributions to the development of the satellite's 60 cm cryogenically-cooled telescope and to the project's scientific data processing system located at JPL.

Whatever the structure of the Vega system ultimately proves to be, it has provided a second case of an attended star: our Solar System being the only other example to date. Like the discovery of rings about Uranus and Jupiter, to supplement the classically-known rings of Saturn, the multiplication of cases of an important phenomenon will eventually produce knowledge to illuminate all instances of the phenomenon. Thus, the distant Vega system may promote understanding of our own origins.

ASTEROID HUNTING

Asteroid discoveries by Eleanor Helin have been reported in "Space at JPL" twice before: in the September-October 1982 issue and last month. This JPL astronomer specializes in the detection of asteroids that come near to or actually cross the orbit of the Earth: the so-called Apollo and Amor classes of asteroids.

Of the almost 3000 numbered asteroids (those with very well determined orbits), only about 55 fall in the Earth-crossing category, and Helin and her associates have found approximately 15 of these. One of her discoveries, designated 1982 DB, is currently the most accessible asteroid for investigation by spacecraft. Of course, the main reason for asteroid hunting is its intrinsic scientific return: helping to better understand the inventory and properties of primitive bodies in the Solar System. However, a side benefit may eventually appear in the exploitation of space since nearby asteroids could prove to be of value as a natural resource. On a less sanguine note, three or four one-kilometre sized asteroids can be expected to strike the Earth every million years and metre-sized asteroids arrive here approximately every 25 years.

Helin, who was trained as a geologist and was an associate of former JPL director Bruce Murray when both were at Caltech, proceeds in a systematic fashion in the task of asteroid hunting. In January 1973 she began the Palomar Planet-Crossing Asteroid Survey (PCAS) and found her first Apollo-class asteroid that July. The 18-inch and 48-inch Schmidt telescopes at Palomar are regularly used in this programme. Supplementary funding for PCAS is provided by The Planetary Society and the World Space Foundation.

In addition to the PCAS work conducted out of Palomar, Helin has been a guest observer and lecturer at observatories around the world. She and Dr. Eugene Shoemaker of the US Geological Survey proposed a joint observing programme through The Royal Observatory of Edinburgh (Dr. Russell Cannon): the United Kingdom/Caltech Asteroid Survey (UCAS). This programme, which extended from February to May 1981, was implemented by Helin and S. J. Bus (JPL). Approximately 1500 asteroids were acquired using the 48-inch Schmidt telescope at Siding Spring in Australia in cooperation with Dr. John Dawe and the observatory's staff. Approximately 1000 of these asteroids were observed for a three-month period which allowed determination of their orbits to an accuracy sufficient to reobserve them at their next appearance. In this fashion, portions of the asteroid bonanza of UCAS will be incorporated into the canonical list of numbered asteroids.

NEWS FROM THE CAPE

By Gordon L. Harris

REMOTE SENSING

Two further Landsats should be orbited by NASA, according to the US Land Remote Sensing Satellite Advisory Committee. The first satellite is available and should be launched as soon as possible, the Committee reported. Consisting of industrial and academic specialists in the field, the panel reported to Malcolm Baldridge, Secretary of Commerce, who asked for advice on the use and operation of Landsats.

President Reagan has said that he prefers to sell both Landsats and meteorological satellites to private sponsors. Baldridge chairs an intergovernment panel studying this concept.

Michael Halbouty, advisory committee chairman, said that his group believes two more satellites are needed to assure continuity of data being collected on crops, mineral deposits, pollution, oceans, river basins and terrain. "We'd like to see commercialization," he remarked, "but we're concerned about continuity and the government should stay in as long as possible."

A newcomer, American Science and Technology Corp, has announced plans to launch an Earth surveying satellite. Meanwhile, US Senator Larry Pressler urged more Landsats and cooperation with the French Probatoire d'Observation de la Terre (SPOT). He wants the US to offer a Landsat data centre in his state as a receiving station for SPOT (due for launch early in 1985). The jobs of one-third of the centre's 300 employees are tied to Landsat.

THE PUBLIC IN SPACE?

With some reservations, a task force appointed by NASA Administrator James Beggs believes that it will be possible and desirable to carry private citizens in future Shuttles flights.

A summary report released on 16 June observed:

"It is feasible to fly individuals beginning in the mid to late 1980's without undue risk to crew safety or accomplishment of the specific mission.

"Seats will be available but there will be competing demands. Planning for a minimum program is the best way to ensure seats.

"Flight experience is not particularly stressful if the person is trained; if trained, he or she could adapt easily to habitability requirements and mission activities.

"Medical requirements will not be as rigorous as for astronauts. They will focus on preventing medical/psychological situations in space hazardous to all involved."

The group believes it is desirable for NASA to fly observers in order to enhance public understanding of space flight. Recognizing the agency's efforts in this direction, the report added:

"Persons who would produce more comprehensive mission documentation and educational material would significantly implement NASA's charter and augment its current activities."

A cautious approach was suggested because of the following considerations:

"It would be easy to misunderstand such a program as a self-serving public relations gimmick . . . despite NASA's well meaning intentions.

"Details for selection of observers need thorough thought because of possibility of litigation and misunderstanding. The selection for the first phase should focus on the probable productiveness of the observers and the widest dissemination of resulting information.

"There are questions of flight risk, liability and control of extraordinary profits . . . observers might be brought in as NASA employees during mission time with the same rights and responsibilities as the flight crew. A portion of personal profits might be given to charity or educational foundation."

The Task Force recommended that NASA undertake to fly observers and mentioned several options such as "visual mission history and real time reports, written and interpretive history covering scientific and technical achievements, or an educator who could teach on science, engineering and biological principles of manned space flight."

SEARCH AND RESCUE

An international search and rescue system for aircraft and boats has been credited with saving 42 lives in less than a year, although it is swamped with false alarms.

Bernard Trudell of NASA said the false alarm rate is 97 percent for aircraft and 50 percent for marine craft. He put the blame upon careless operators and bad equipment. Colonel Peter Warn, director of the Inland Search and Rescue Center at Scott Air Force Base in Illinois admitted the false alarms "are driving us nuts" but objected to criticism that they destroy its usefulness.

Two Soviet and one US satellites rebroadcast emergency beacon signals which all non-commercial aircraft and commercial ships must carry. Each satellite makes six passes daily over the continental US and relays signals to Earth.

NASA and the US Air Force would like to require all pilots to ensure their radios are tuned to 121.5 MHz before takeoff. The Federal Aviation Administration considers that unenforceable.

MORE EXTERNAL TANKS

A $505 million three-year contract has been awarded to Martin Marietta for 26 more Space Shuttle External Tanks and the purchase of raw materials for 21 additional tanks. Each tank is 47 m long, 8.5 m in diameter and carries 2 million litres of propellant for the main engines.

The company was already under contract to provide 15 complete tanks, three for tests and 12 for flight. The final tank was due to be shipped to the Kennedy Space Center last September.

WHAT'S NEW IN THE LIBRARY

First Day Covers

We have made good progress with our display collection of First Day Space Covers, thanks to Lester Winick and Rex Hall. Lester provided a marvellous collection of American First Day Space Covers and went to a great deal of trouble on our behalf. Rex did just the same thing, though concentrating on Soviet First Day Covers.

A piece of good luck came along when we found a batch of albums to hold them at a very cheap price. This was not all. Bill McLaughlin gave us a fine book on Space Stamps to underline the fact that, besides the collection, we need reference books to go with them! Bill, incidentally, also took time off from his holiday in France to locate several more unusual space covers for us.

Books

Many members have helped us recently, with Arthur Clarke heading the list with a gift of no less than ten autographed science-fiction works to help us create this new area in our collections. Two other authors also featured in gifts, with Dr. Fredric Taylor presenting a copy of his *Photographic Atlas of the Planets* and Tim Furniss his *Manned Spaceflight Log* which, incidentally, not only refers to the Society but gives its address and is an absolute model of just the sort of thing we would dearly like all of our author-members to do. Jim Oberg gave us some unusual NASA material while Jim Burke and Charles Vick sent some books on planetary exploration and the Soviet Space Programme, respectively.

The present status of our collection is as follows:

	Total at 31.8.1983	*Total at 3.3.1983*
Books	2278	2215
Reports	4281	4230
	6559	6445

Most of the books we now need are out of print, even if published relatively recently, hence the growing list of items listed in Desiderata and which, hopefully, members will help us to locate.

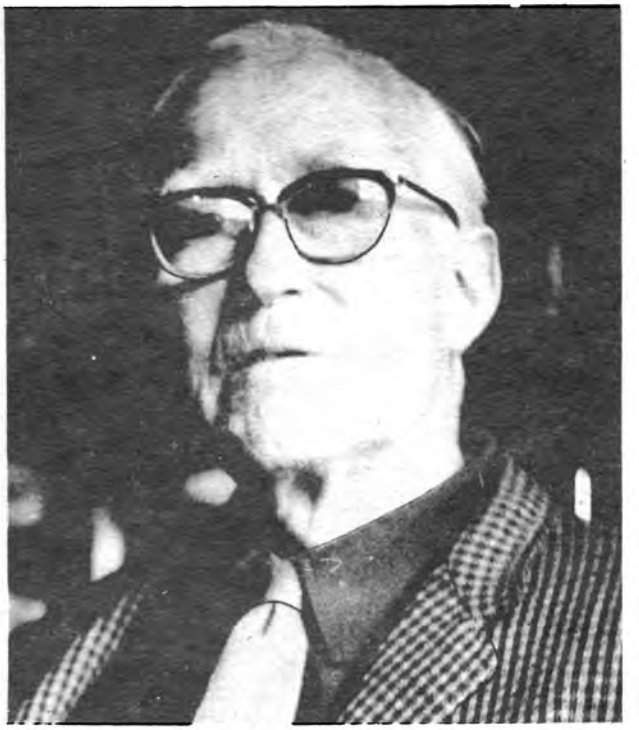
There are decades of arrears to make up, if we include all those years before our Society began yet which produced material we ought to own if we are to justify our position as a premier space body with an international reputation.

Currently, we are seeking:

a. Specialised (not general) works on planetary and lunar astronomy, including comets and meteors; star catalogues, etc.
b. Pre-1960 books and reports on rocketry and space technology. Many of those published in America during this period were never easily obtainable in the UK, hence our difficulty in securing copies.
c. Pre-1860 books on Science Fiction.

We are also trying to secure a number of items for future displays. These include:

a. Sets of cigarette and similar cards.
b. Admission badges to various space functions, particularly those including the name of the person attending.
c. Apollo 11 and similar souvenirs, small space artefacts, interesting photographs etc. Regarding photographs, we are particularly interested in V2 and early post-war prints and feel sure that some members must own piles of old space photographs which are bursting to see the light of day once more through the medium of our pages. Another acute need is for photographs of the Second London Congress in 1959. The photographer engaged on that occasion undertook to provide the Society with a print of each picture. Unfortunately, his business collapsed soon afterwards so we never got our prints. Can any member help to fill this gap?
d. Coins, medallions, first day covers and similar souvenirs of astronomy or space occasions.



Our thanks go to Horace Dall for a generous contribution towards extending our astronomical section, and his support to the Society over many years.

Artefacts

By far the biggest collection of artefacts came *via* SERC as a result of the work put in by Gerry Webb to project them in our direction. The cache consisted of several Skylark nosecones, parts of instrument bays, assembly rings, and much ancillary material. These will all be used for a future display.

At the other end of the scale we received a piece of stainless steel, as used in the Atlas rocket, donated by Curtis Peebles and Hank Guthauser.

Colin Ledsome produced a prototype of the waist seal for the Lower Body Negative Pressure device used aboard Skylab, while Francis Tallentire brought over several extremely interesting space artefacts from the Shuttle booster recovery programme, as well as some excellent first day covers. Further sets of cards arrived from Dave Shayler and Douglas Arnold.

We are very pleased to acknowledge all these fine gifts.

Society Historical Records

It is strange to realise that our Society, in spite of its long history, has practically no Society historical

The old Society's offices in Bessborough Gardens was not an ideal place for establishing an archive.

records. The explanation is not far to seek. Before the war we had a small membership and no proper "home". It was not until 1952 that the Society rented a single room — to encompass its staff, typewriters, files, stationery, stocks of magazines and everything else which could be piled in. It was essential that "incomings equalled outgoings" to prevent the floorboards collapsing under the weight. No-one wished to disappear, involuntarily, into the cellar. Actually, the front of the building gradually bulged outwards though, at the time, we stoutly maintained that the weight on the floorboards kept it from becoming a second Leaning Tower.

With problems of self-preservation so acute, materials were kept to bare essentials. Now, we have a small room for Society records. Shelving is being obtained so we will soon begin to approach long-standing members to see if they can provide anything for us.

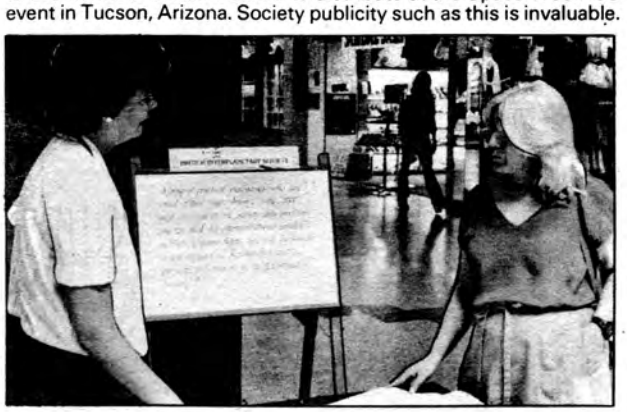
Library Book Sale

In spite of our best endeavours we have managed to accumulate a stock of extra copies of a number of books and reports on astronomy and space, all of which are now being offered for sale to obtain funds to acquire volumes needed for our collection.

A list of everything for sale can be obtained from the Executive Secretary on request.

Our Library is now well-used, as the following letters show. Visitors even arrive from abroad wanting to use it, though pre-eminent is its value to every member in giving us a source of reference and information to support our publications.

We were pleased to send a batch of Society magazines and material to BIS member William Ganoe to distribute at the Space Week '83 event in Tucson, Arizona. Society publicity such as this is invaluable.



The information I obtained from the BIS Library was extremely useful in helping me to do my MS project in Atmospheric Re-entry which I have just completed.

Alan Lawrie

I enjoyed my visit to BIS HQ and Library recently. Quite a range of reading matter of all kinds.

I managed to find a few little titbits on the matter of "Mr. — and the Martian". I'm sure you never imagined that the BIS Library might be used for such a bizarre piece of research!

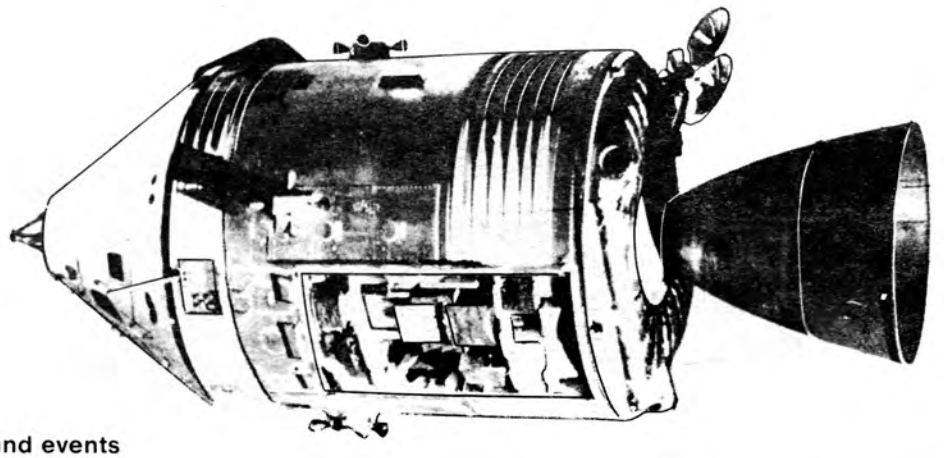
Christopher D. Allen

I am grateful for help from the BIS Library in studying the cost of producing a space colony for application to interplanetary travel, as background to an article I am preparing on Interstellar Arks.

Tim Grant

DESIDERATA

Author	*Title*	*Date*	*Publisher*
F. Bailey	An Account of the Revd. J. Flamstead	1966	Dawsons
A. & P. Beer	Kepler – 400 years	1975	Pergamon
P. L. Brown	Comets – Meteorites	1974	Taplinger (N.Y.)
I. B. Cohen	Newton's Theory of the Moon's Motion	1975	Academic Pubs.
A. H. Delsemme	Comets, Asteroids, Meteorites	1977	Univ. of Toledo Press
G. de Vaucouleurs	Reference Catalogue of Bright Galaxies	1964	Univ. of Texas
J. L. E. Dreyer	Tycho Brahe	1963	Dover
M. 'Espinasse	Robert Hooke	1956	Univ. of Calif. Press
E. G. Forbes	The Gresham Lectures of Jon Flamsteed	1975	Mansell Pub. Ltd
C. D. Hellman	The Comet of 1577 – Its Place in the History of Astronomy	1971	AMS Press (or Columbia Univ. Press 1944)
H. Jeffers & W. Van de Bos	Index Catalogue of Visual Double Stars	1963	Lick Observatory
J. Kepler	Somnium (Trans)	1967	Univ. of Wisconsin Press
G. P. Kuiper & E. Roemer	Comets: Scientific Data & Missions	1972	Univ. of Arizona Press
F. E. Manuel	Portrait of Isaac Newton	1968	Harvard Univ. Press
L. T. More	Isaac Newton	1962	Dover
H. H. Nininger	Arizona's Meteorite Crater	1956	American Meteorite Museum
C. A. Ronan	Astonomers Royal	1969	Doubleday
S. W. Smith	A Handbook of Astonautics	1967	Univ. of London Press
H. J. Steffens	The Devpt. of Newtonian Optics in England	1977	Neale Watson Academic
J. W. Sulentic & W. G. Tifft	Revised New General Catalogue of Nonstellar Astronomical Objects	1973	Univ. of Arizona
T. von Oppolzer	Canon of Eclipses	1962	Dover
R. S. Westman	The Copernican Achievement	1975	Univ. of Calif.
H. Woolf	The Transits of Venus	1959	Princeton Univ. Press (or Arno Press).
F. Zwicky	Catalogue of Galaxies and of Clusters of Galaxies (2 Vols.)	1961/3	C.I.T.
	Reference Catalogue of Bright Galaxies	1964	Univ. of Texas
	Star Atlas of Reference Stars and Nonstellar Objects	1969	MIT Press



SPACE REPORT

A monthly review of space news and events

GALILEO PROBE TEST

The Galileo Jupiter Probe came through a realistic test with flying colours this summer, according to project officials at NASA's Ames Research Center in California.

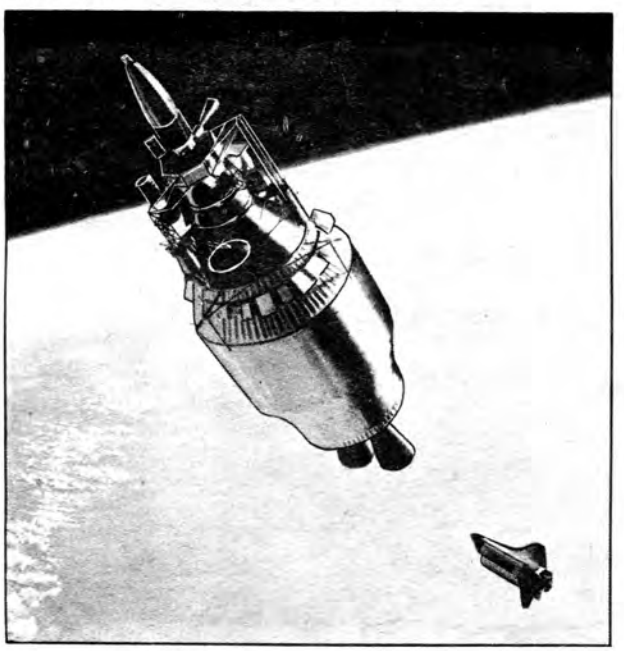
During the test, beginning 30 km above the Earth, the entry craft duplicated the critical operations of flight through the outer fringes of Jupiter's atmosphere by flying through comparable conditions in the Earth's upper atmosphere. The probe was lifted to its test altitude by a 150 m-tall balloon.

The combined Galileo spacecraft will be launched to Jupiter in mid-1986. It consists of an orbiter and atmosphere probe, and will reach the planet in late 1988. The probe will make the first entry into the atmosphere of an outer planet.

The probe will separate from the parent spacecraft 150 days before arrival at Jupiter, and will plunge 300 km into the giant planet's atmosphere. It will penetrate far below the swirling clouds to a pressure level 20 times higher than that on the Earth's surface. Information obtained during the descent will be transmitted to the overflying orbiter, which will then relay it to Earth.

Scientists are curious about the composition of Jupiter's atmosphere and the dynamics of its clouds. This information will help us to understand the evolution of the Solar System, our weather on Earth, and about Jupiter itself.

Launch of the Galileo Orbiter and Probe in 1986.



The probe systems used in the July test are critical to entry operations. Entry will involve deceleration from 185,000 km/h to 80 km/h – or 400 g (400 times Earth gravity). This is so severe that half of the craft must be heat shield.

Following deceleration, a pyrotechnic device fires to deploy the pilot 'chute, removing the probe's aft cover. The cover separates and pulls the main 'chute out of its canister.

After the main 'chute is fully inflated, the heat shield separates. Time for all this is 10 seconds. The instrument capsule then drifts down with its parachute to 300 km below Jupiter's bright clouds.

For the purposes of the July test, the properties of the top of the Earth's atmosphere are identical to those of Jupiter's upper atmosphere. The balloon was launched by the Air Force Geophysics Laboratory, with the probe recovered at the Army's White Sands Missile Range in New Mexico.

The test showed that the main parachute will be fully open at heat shield separation, abruptly slowing the instrument capsule so that the burned-out heat shield will fall rapidly away, allowing instrument deployment and atmosphere measurements uncontaminated by gases from the high-temperature heat shield.

IRISH EARTH STATION

Ireland is rapidly modernising its telecommunications facilities to prepare the way for ESA's satellite programmes planned between now and 1990, writes Brian Harvey. Ireland's first Earth station will be completed by the end of next March at Elfordstown, near Midleton, Co. Cork. Its main 32 m dish will have a tracking accuracy of 0.02 degrees; signals will be relayed by a 120 m high steel tower *via* microwave to the switching station at Churchfield in Cork city.

The station will be linked to an Intelsat 5 satellite connecting to Andover, Maine. As well as the telephone circuits, the state television service will have a permanent TV and sound video channel to North America. The whole Earth station project will cost about £5.5 million.

Apart from this government-sponsored initiative, University College Cork has performed experiments related to Direct Broadcast Satellites. It has used a small 1.2 m dish to pick up three channels from the

Soviet Gorizont (Horizon) satellite and, more recently, a dish twice the size demonstrated Moroccan and Argentinian TV from an Intelsat 5.

Direct broadcasting is believed to hold certain commercial potential in Ireland. Unlike elsewhere in Europe, most Irish homes can receive only the two state channels. Cable operators are able to retransmit all the British stations in the Dublin area, and there is heavy demand for such services; but they are neither commercially or technically feasible further west. Direct broadcasting receivers using small 1 m dishes would overcome both these problems.

SALYUT STRUCK BY DEBRIS

The dangers of striking high speed debris in orbit was brought home to the two Salyut 7 cosmonauts, Vladimir Lyakhov and Alexander Alexandrov, at the end of July when they heard a loud crack and found a 4 mm diameter crater in one of their windows. At the time the crew was preparing a run-through of procedures for evacuating Salyut during emergencies – a job that would take at least 15 minutes, according to news reports. There was no danger this time, though, because the damaged window is made of two 14 mm-thick layers of specially toughened glass.

The US Shuttle Orbiter *Challenger* needed a new window pane following similar damage during the seventh Shuttle mission. Neither incident can be blamed on man-made debris; indeed, Soviet scientists believe there was a meteoroid shower at the time of their strike.

Meanwhile, the two Indian pilots, Wing Commander Ravish Malhorta and Squadron Leader Rakesh Sharma, are continuing their cosmonaut training for one of them to fly to Salyut 7 during the first half of next year.

SOVIET SOLAR POWER SATELLITES

A Soviet Solar Power Satellite, called SES and weighing 80,000 tonnes, is now seen as a space project for the 21st century, writes Brian Harvey. The proposal has been put forward by Professor S. Grishin; he foresees about 15 per cent of the Earth's energy demand being met by solar power satellites within a hundred years.

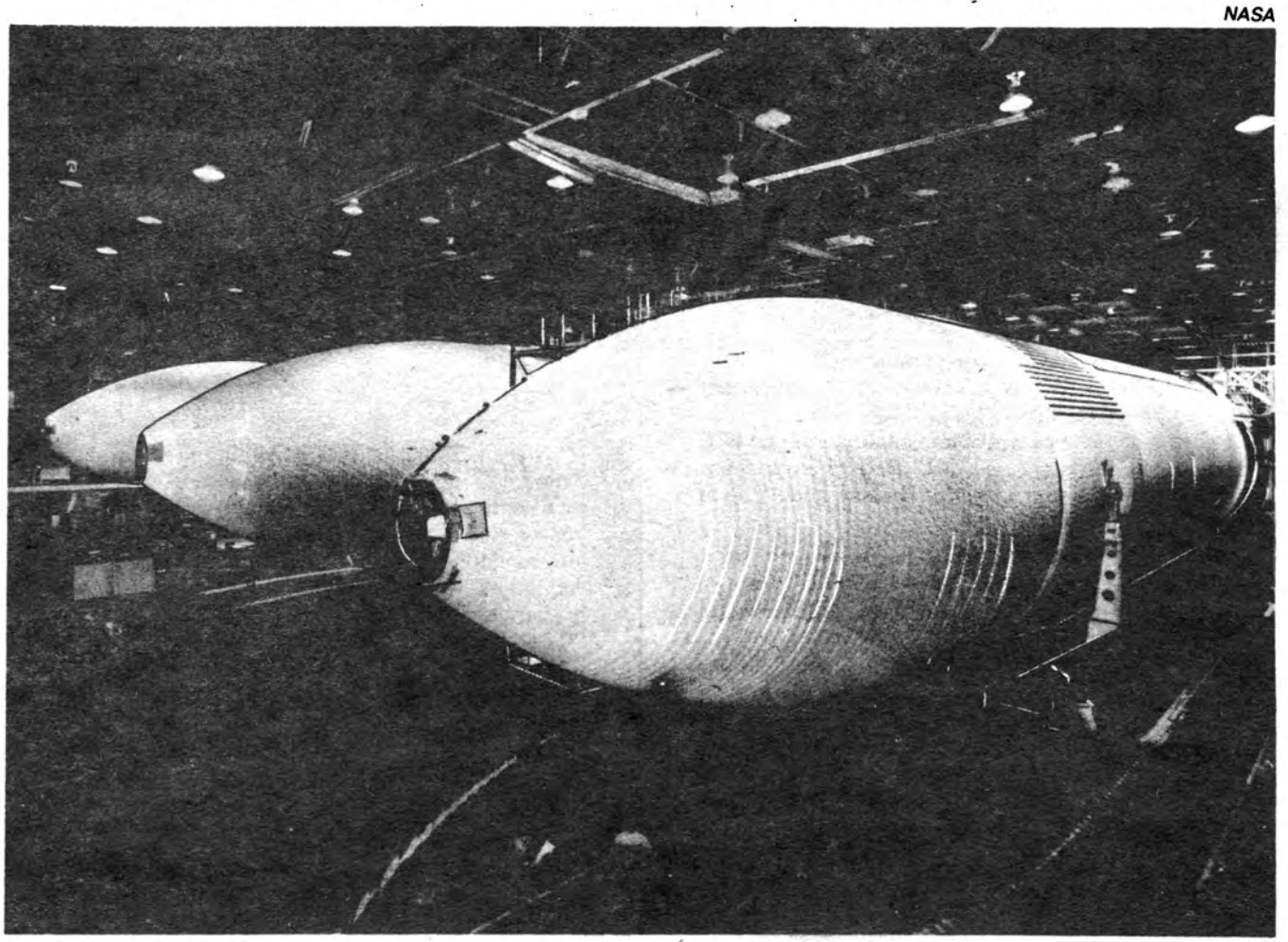
His SES would have a generating capacity of 10 GW, compared to the output of 4 GW of the Leningrad Atomic Power Station, presently the world's largest single energy source. The area of SES would be 40 km^2. The SES would be assembled from sections weighing between 100 and 500 tonnes.

New types of solar cells, wrote Prof. Grishin in *Soviet Weekly*, would improve radically on present day cells whose efficiency is only 10–12 per cent and can produce only 140–170 W/m^2. Come the 21st century, he romantically suggests, "new constellations will flare up in the night sky," providing energy by a method that is "ecologically the purest of all."

Looking like a line of beached whales, the External Tanks intended for Shuttle missions 11 to 13 lie in the final assembly area at Martin Matrietta's Michoud Div. near New Orleans. Each of the 47 m long, 8.4 m diameter tanks will carry a quarter of a million litres of liquid hydrogen and oxygen.

A recent report indicated that the target production rate of 24 per year (more are scheduled for delivery next year) will probably be met. At the end of June three tanks were at the Kennedy Space Center awaiting use while another 12 were in various stages of assembly at Michoud.

NASA



NUCLEAR BLAST DETECTORS

The nuclear explosion monitoring duties of the ageing Vela satellites will be taken over by the new Block II Navstar military navigation satellites beginning in 1986, writes Joel Powell. Each of the 28 Block II satellites will carry sensors to detect illicit nuclear tests and to assess nuclear attacks in the event of war. The supplementary packages are known as IONDS – Integrated Operational Nuclear detonation Detection System – and will be interconnected by UHF radio. Navstar Block II will be launched by the Space Shuttle and the PAM-D2 apogee motor.

DELTA STAGES FOR SHUTTLE?

The problems that beset the Inertial Upper Stage following its launch from STS-6 in April have prompted the Goddard Space Flight Center to study the use of their Delta rocket upper stages aboard the Space Shuttle instead.

The IUS second stage failed to take the large TDRS communications satellite to geostationary altitude, leaving ground controllers to use the satellite's own tiny thrusters. Although the failure was known to be connected with the engine gimballing mechanism, the exact cause could not be identified. This meant that the second TDRS was removed from STS-8's manifest for August and STS-10 was cancelled because a third IUS was to have been used for a military payload.

Goddard's studies show that it is possible to use the second and third stages from the Delta 3920 launcher as Shuttle upper stages. The estimate is that a system could be ready by the end of next summer if the IUS problems remain unsolved.

LONDON'S SATELLITE TERMINAL

British Telecom International is to build a satellite Earth station at North Woolwich in London. Known as London 1 and London 2, the antennae will provide leased line services for the transmission of television programmes. Working in the 11/14 GHz frequency band, each consists of a 13 m dish and a container housing all the electronic equipment, including high-power amplifiers, ground communication equipment and low-noise amplifiers.

One antenna will operate in conjunction with an ECS satellite, while the other will work through an Intelsat V Atlantic Ocean region satellite. The site should be in operation in early 1984.

VETERANS AT THE CAPE

A group of Cape pioneers was on hand to witness the eighth Space Shuttle launch on 30 August as part of their celebrations to mark the 30th anniversary of the first Redstone rocket flight.

They were the surviving members of the launch team for the Army's first Redstone ballistic missile launched from Complex 4 at what is now Cape Canaveral Air Force Station on 20 August 1953.

The anniversary would have coincided exactly with the planned 20 August launch date of the STS-8 mission but a 10-day Shuttle slip brought about the decision to slide the commemoration 10 days to give the celebrants an opportunity to view the Shuttle's first night launch.

Mary Johnston (also pictured in last month's magazine) is in training as a Spacelab 3 Payload Specialist. The mission is now scheduled for late 1984.

NASA

Some 90 members of the US Army's Redstone Arsenal at Huntsville in Alabama were involved in the mission and many of them joined NASA when the agency was created in 1958. One of them, Dr Kurt Debus, became KSC's first director; another, Dick Smith is the present director.

The Redstone 1 development flight was visible for 42 seconds on that day 30 years ago before disappearing into a cloud bank. The missile was destroyed on ground command after 106 seconds because of its erratic flightpath.

NEW INMARSAT SYSTEM

The International Maritime Satellite Organization (Inmarsat) has called for tenders on a new communications satellite system which could cost several hundred million dollars. Inmarsat, which provides satellite communications to the worldwide shipping and offshore industries, requires a new satellite system from 1988 to handle expected increases in the numbers of users of its system and to offer new services.

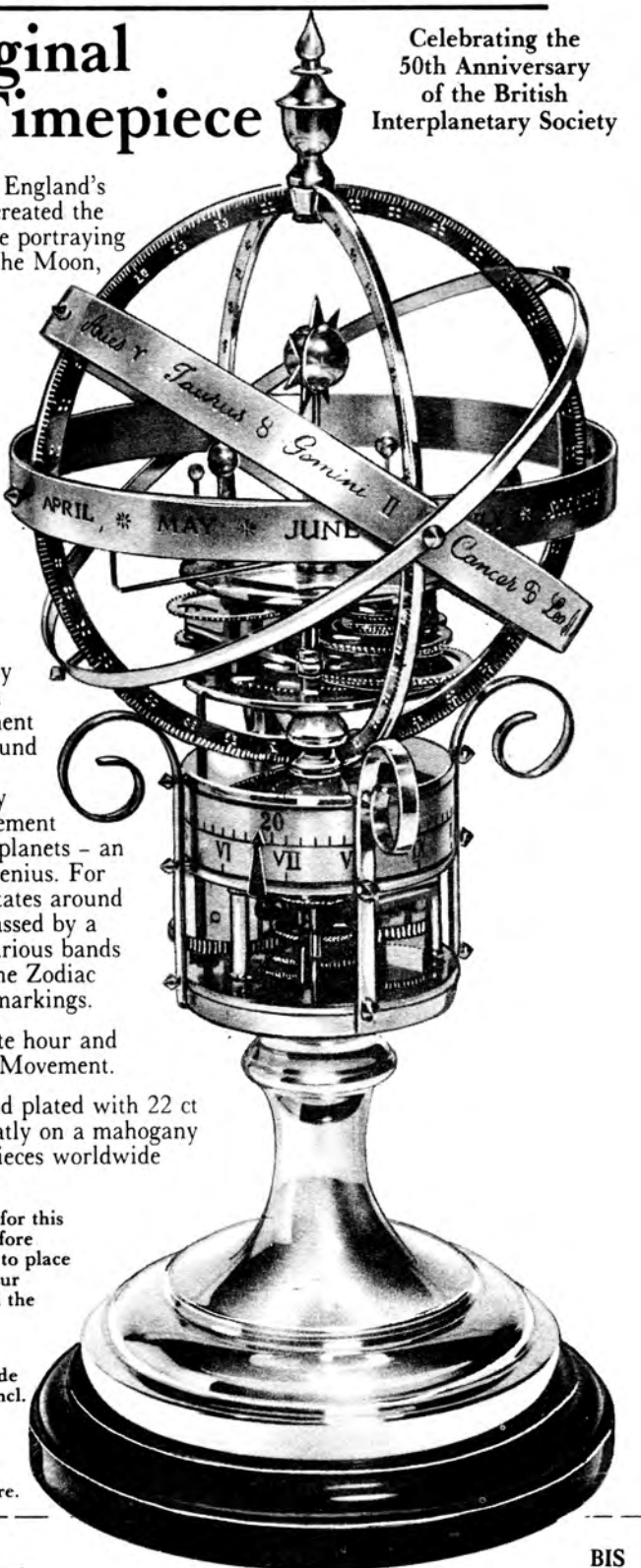
The new second-generation satellite system would replace Inmarsat's existing satellite system, which includes capacity leased on nine satellites, three of which are to be launched over the next 12 months. Depending on which option is selected, Inmarsat could be ordering as many as nine satellites, which would be launched over a three-year period starting in the second quarter of 1988.

The spacecraft must be compatible with more than one launcher from the list of Ariane, Proton, Shuttle, Delta, Atlas Centaur and Titan.

THE ORRERY CLOCK

An Original Collectors Timepiece

Celebrating the 50th Anniversary of the British Interplanetary Society



In 1710 George Graham, one of England's most distinguished clockmakers created the first Orrery – an ingenious device portraying the relative motions of the Sun, the Moon, the Earth and the Planets.

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REACHING THE FURTHER STARS

OVERCOMING THE BARRIERS OF TIME AND SPACE

By David Froning

The Pioneer 10 spacecraft has travelled farther in space than any known object ever launched from Earth. Yet, although this craft has journeyed over 4000 million km in over 10 years, it would have to travel more than 10,000 times farther to reach the nearest star. And the more distant stars are much farther still – with the more remote stars of our galaxy being 10,000 times farther than the nearest star, and the stars of the more remote galaxies being a million times farther still. Incredibly high speeds would be needed to traverse these stupendously long distances within the lifetime of a starship's crew.

Introduction

The overwhelming consensus within orthodox science is that material objects can travel at speeds up to about 300,000 km/s – the propagating speed of light. At first glance, such an enormous speed limit seems very generous, since it is more than 200,000 times faster than the fastest spaceship we have ever launched from Earth, and it would permit us to traverse our entire Solar System in less than half a day. But it takes 4.3 years for light to travel the 40×10^{12} km to the nearest star, and over 30,000 years to traverse the 3×10^{17} km to the centre of our galaxy. Furthermore, light takes millions of years to traverse the enormous gulfs of space separating us from nearby galaxies, and it would take thousands of millions of Earth-years for light to race over the even longer distances that separate us from the farther stars. The human life-span and the finite speed of light therefore appear to limit even the swiftest human to distances less than about 100 light-years from Earth. And, of course, such a radius of action is infinitesimal compared to the stupendous vastness of cosmic space.

But although the farther stars are millions of light-years from Earth, are they really separated from us forever? Are these stupendous gulfs of time and space truly barriers that can never be overcome? Or, are these so-called "barriers" merely beliefs of limitation – beliefs that will be proved erroneous as mankind delves deeper into the mystery of matter, time and space?

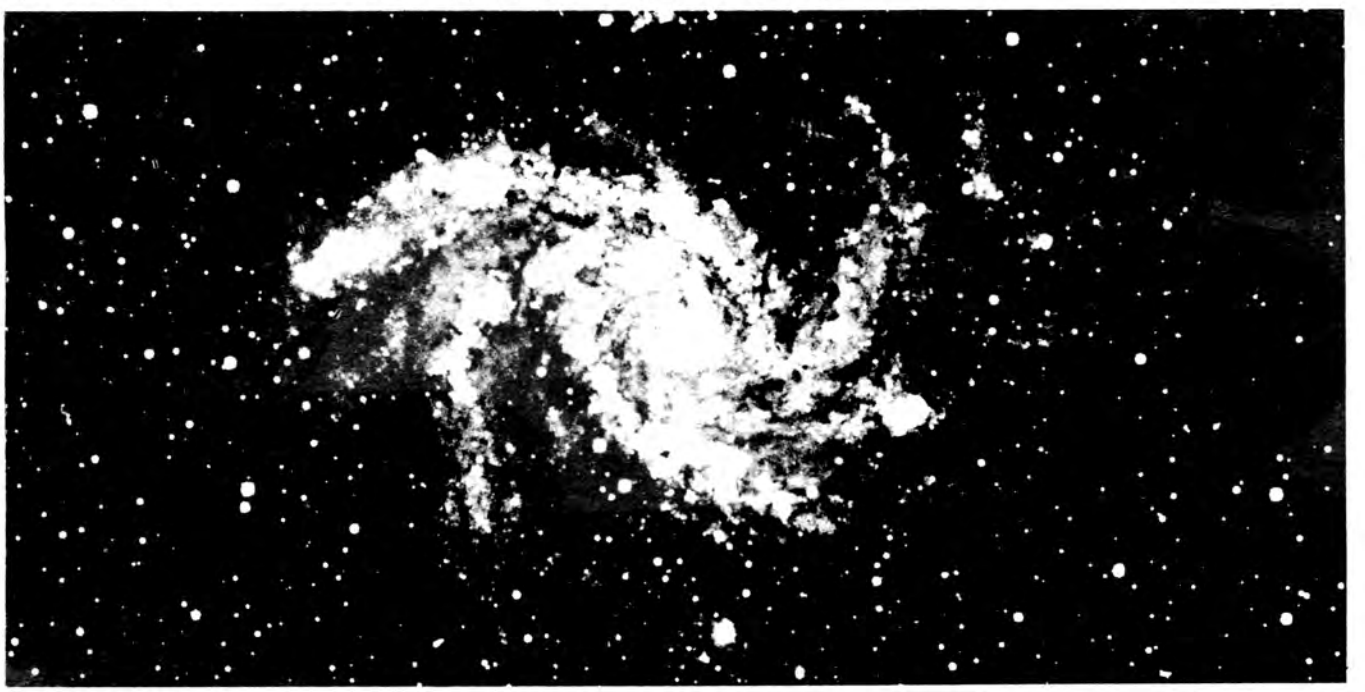
Today, of course, our scientific knowledge and understanding are insufficent for answering these questions. Very few scientists would be so bold as to declare the absolute impossibility of reaching distant stars. Even fewer would be so foolhardy as to proclaim that it can be done. Nevertheless, although we cannot claim that man will ever reach the outermost limits of cosmic space, let's try to see what would have to come to pass in order for him to do so. In particular, let's see what would have to happen within our cosmos so that spacefaring men might reach out and, within a human lifetime, return to Earth from the farther stars.

Faster-than-Light Travel

Relativity tells us that starships that could quickly accelerate to nearly the speed of light could reach stars within short intervals of time, as measured by their clocks and by the physical aging of their crews. But millions of years would have elapsed on Earth during such trips – with the birth, life, and death of many generations occurring long before the crews of such ships could return and share the results of their journeys with those who made the journey possible. And it is difficult to envisage a technological society so altruistic as to invest huge resources on explorations whose outcomes would not be known until later generations.

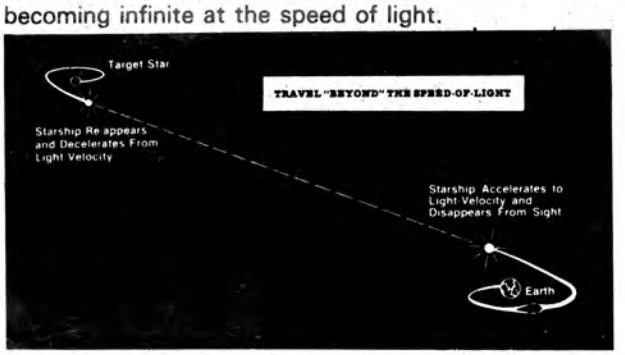
But if starships could race at speeds of thousands of times faster than the speed of light, they could reach and return from distant stars within the life-spans of those who remained on Earth; and, although the present consensus of scientific opinion is that no object can exceed the speed of light, there might be some hope of this if such "superluminal" speeds could be achieved by starships in space, just as "supersonic" speeds are achieved by aircraft within our skies.

Spiral galaxy NGC 6946 in the constellation of Cephus. *Kit Peak National Observatory*



In this respect, there might be an interesting similarity between the faster-than-sound speeds of supersonic aircraft and faster-than-light speeds of superluminal starships. Just as the more simplified theory of relativity (Special Relativity) predicts that a starship's resistance to motion (its inertia) becomes infinite at the speed of light, so the more simplified theories of aerodynamics predict that an aircraft's resistance to motion (its drag) becomes infinite at the speed of sound.

However, in reality, the flow pattern about an aircraft begins to change as its speed begins to closely approach sonic speed – with this change in flow (which is not accounted for in the more simplified theories) preventing resistance to aircraft motion (its drag) from becoming infinite at the speed of sound. Then it follows that some analogous change in state must begin to occur as a starship's speed begins to closely approach light-speed – with this change in state (which would not be accounted for by Special Relativity) preventing resistance to starship motion (its "inertia") from becoming infinite at the speed of light.


Target Star
TRAVEL "BEYOND" THE SPEED-OF-LIGHT
Starship Re-appears and Decelerates From Light Velocity
Starship Accelerates to Light Velocity and Disappears From Sight
Earth

Our analogy between supersonic and superluminal flight is, of course, not exact, because it is the flow around the aircraft, and not the aircraft itself, that has to change during transition to supersonic flight. On the other hand, the starship itself may also have to change during transition to superluminal flight, and for travel beyond the speed of light, this transformation might be manifested in starship acceleration to light-velocity and disappearance from human sight. Then, sometime later, the ship would reappear trillions of kilometres away and decelerate from light-velocity in the proximity of its target star.

Our Realm of Space and Time

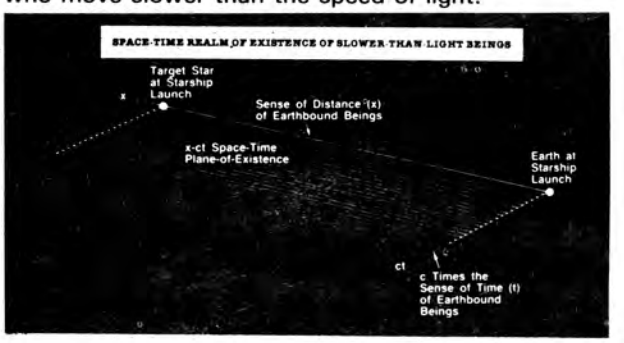
Although we have considered the possibility of starships exceeding the speed of light the consensus of opinion is that such travel is impossible because it would violate theories, such as Einstein's Special Relativity. But even if such theories were true, they would only be valid within that space-time realm of existence that we call our "physical world"; therefore, they would not be violated if the faster-than-light segments of starship journeys could take place outside this space-time realm.

Because of this, some advocates of faster-than-light travel suggest that it takes place within a realm of existence that is outside the breadth, length, height, and depth of three-dimensional space and one-dimensional time. And although orthodox science tends to be somewhat sceptical of such a realm, numerous science fiction writers have enthusiastically accepted it for their stories and have given the name "hyperspace" to a postulated realm of existence, which lies beyond the speed of light.

Now, even if there is a hyperspace outside our realm of space and time, we have no way of describing the essence of something that transcends our conceptions of space and time. Nevertheless, we can symbolise the deeper dimensionality of a hyperspace by first symbolizing the lesser dimensionality of the space and time of our familiar physical world.

First, let's represent our sense of three-dimensional space by the symbol (x) and our sense of time by the symbol (t). Next, let's measure distances between persons, places, and things in three-dimensional space along an x-coordinate. And let's measure the passage of time during travel between persons, places, and things along a ct-coordinate – with ct being in units of distance (like x) by being c (the speed of light) times t. Finally, let's visualize the x- and ct-coordinates as being at right angles with respect to each other and as emanating from the "here" and "now" of our present location on Earth.

Now, modern science shows that the distances of space and the tempos of time are not independent of each other, but, rather, are interwoven into a single fabric of space and time which contains all spatial and temporal sense perceptions of all beings who move slower than light with respect to Earth. Then, for our simple representation, let's view this space-time fabric as a land with our x- and ct-coordinates forming the boundaries of this space-time land. Next, for simplicity, let this two-dimensional land possess the flatness of a plane. Finally, let this two-dimensional plane symbolize the space-time plane of existence of all beings who move slower than the speed of light.

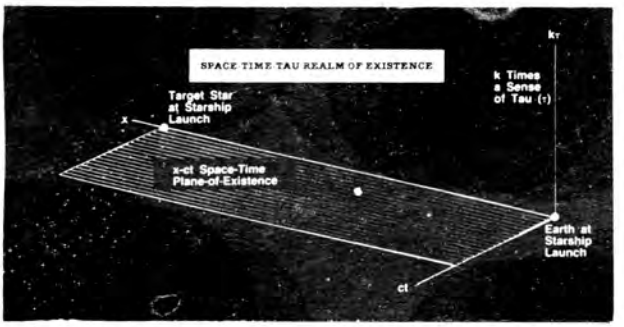

SPACE-TIME REALM OF EXISTENCE OF SLOWER-THAN-LIGHT BEINGS
Target Star at Starship Launch
x
Sense of Distance (x) of Earthbound Beings
x-ct Space-Time Plane-of-Existence
Earth at Starship Launch
ct
c Times the Sense of Time (t) of Earthbound Beings

The Deeper Realm of Hyperspace

Some people visualize hyperspace as a realm with more spatial dimensions than the three dimensions of "normal" space, and others visualize it as a realm with more temporal dimensions than the single dimension of "normal" time. And this is natural because it is difficult to conceive of things that do not involve distance or time.

However, although everything that is perceived by the material senses seems to involve "passage of time" and "distance in space", let's try to imagine a sense of something that has nothing to do with distance in space or passage of time. Although the essence of this something is as yet unknown, let's call it "tau" and give it the symbol τs.

Now, because tau has nothing to do with distance or time, its essence cannot be measured in units of distance or time. However, just as we multiplied time by a constant (c) to obtain a quantity (ct), which is in units of distance, so let us multiply tau by a constant (k) to obtain a quantity (kτ) that is in units of distance. And just as we have visualized "the passage of time" as occurring along the ct-coordinate, so let us visualize "the unfoldment of tau" as occurring along the kτ-coordinate. Finally, since tau has no correspondence with either distance or time, the kτ-coordinate that symbolizes it must be at right angles to the x and ct ones. Therefore, we can visualize the kτ-coordinate as



rising vertically above the x-ct space-time plane.

Now the "height" of the kτ-coordinate forms a realm of three dimensions that extends above the two dimensions of the x-ct space-time plane. Thus, just as "sky" is that which extends above the length and breadth of the surface of the Earth, so "hyperspace" is that which extends above the space and time of our physical world. And, just as the sky has length and breadth and height, so our hyperspace has length and breadth and height – the length of space, the breadth of time, and the height of tau. Furthermore, just as the deeper dimensionality of the sky gives aircraft room to travel faster than sound above our Earth, so the deeper dimensionality of hyperspace would give starships room to travel faster than light above our physical world.

In summary, our so-called "hyperspace" is a realm of deeper dimensionality than the breadth, length, and depth of three-dimensional space and one-dimensional time; and, although we have symbolized this hyperspace by the simple euclidian geometry of a three-dimensional euclidian space, the three dimensions of this space represent distance, time, and an unknown essence, tau. Thus our hyperspace is more than space because it not only contains distance but time and tau as well.

Starship Paths in Space and Time

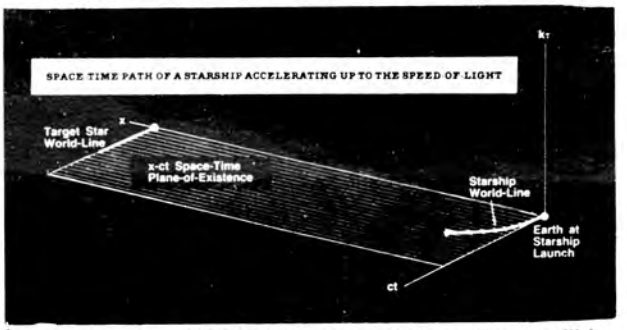
One way of recording the space-time history of a starship's journey to a star would be to measure the distances it travels along the x-coordinate and indicate the times that would be associated with these distances by appropriate markings upon the x-coordinate. However, a more elegant way would be to display the path that the starship traces out in space and time upon the x-ct space-time plane.

We can visualise this path, which would be traced out upon the length and breadth of this space-time plane, by visualising the path of a boat that is crossing the length and breadth of a swiftly moving stream. In this respect, a boat that is crossing a swiftly moving stream would attempt to proceed directly across the stream towards a point on the opposite shore. But it would never reach this point, because currents will cause the boat to be swept downstream from the point by the time it reaches the other shore. This sideways drift will, of course, be the speed of the current multiplied by the time it takes the boat to cross the stream. Thus the path of the boat will not be a line that proceeds directly across the stream, but, rather, a line that proceeds diagonally across it until the boat reaches the opposite shore.

Similarly, let's visualise the surface of our space-time plane as containing the invisible currents of a moving stream. Let the currents of this stream be flowing at the speed of light in the time direction of the ct-coordinate. Thus, as a starship proceeds through space towards its target star, it moves "forward" in the distance direction of the x-coordinate while being swept "sideways" in the time direction of the ct-coordinate. And, of course, the starship's sideways drift in the time direction of the ct-coordinate will be the speed of light times the time it takes the ship to reach its target star.

Therefore, the starship's path will not be a line that proceeds straight "ahead" along the x-coordinate, but, rather, it will be a line (a "world-line") that proceeds diagonally across the x-ct plane.

Now, the path of a boat whose speed is ever



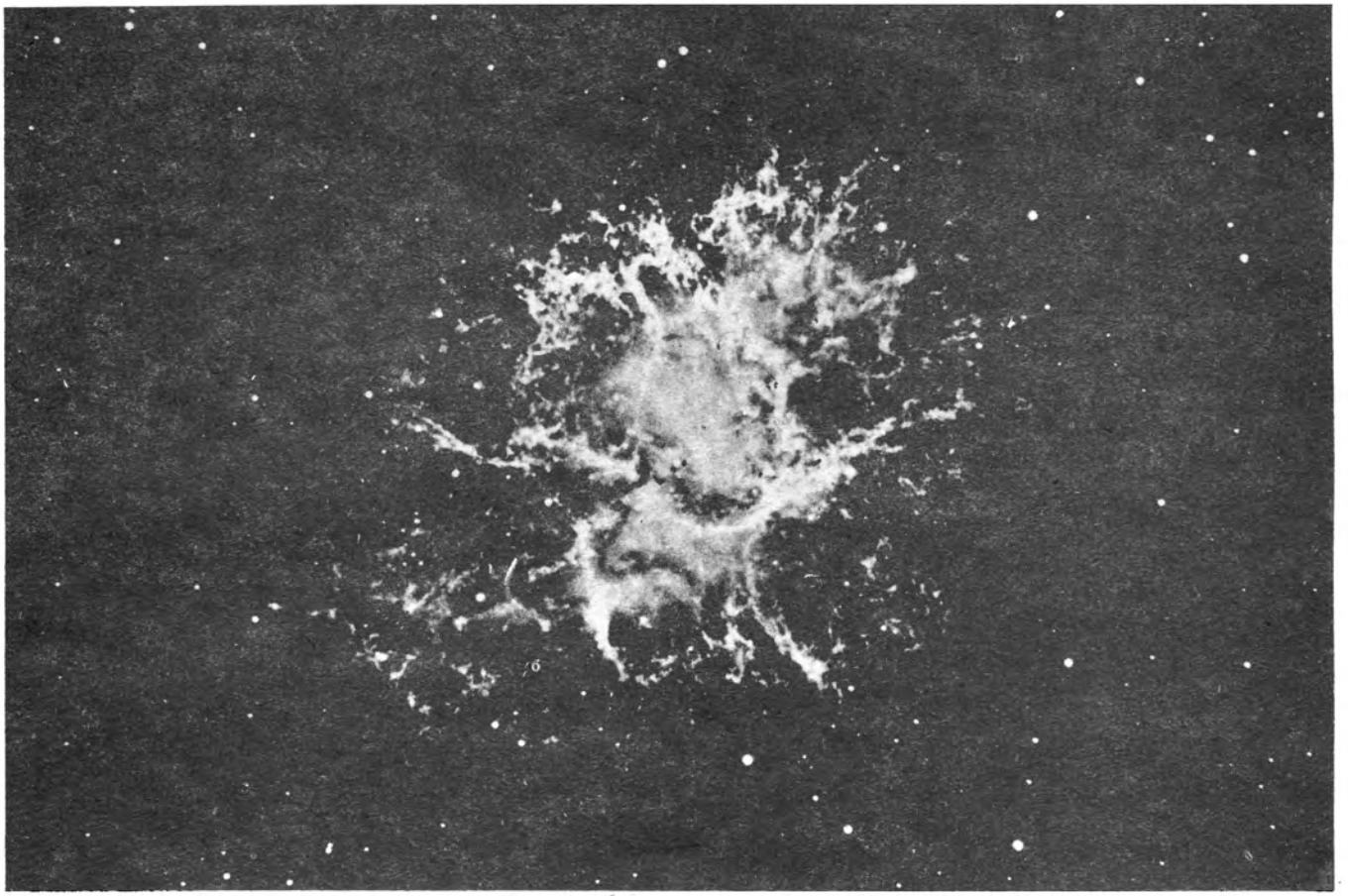
increasing as it travels towards a distant shore will be a *curved* line that proceeds diagonally across a moving stream. Similarly, the space-time path of a starship, whose speed is ever increasing as it travels towards a distant star, will be a curved world-line that proceeds diagonally across the x-ct space-time plane. Therefore, the path that would be traced out upon our space-time plane of existence by a starship that has left Earth and is accelerating up to the speed of light will be a curving world-line that proceeds forward in the distance direction of the x-coordinate and "sideways" in the time direction of the ct-coordinate until it reaches the speed of light.

Starship "Jump" in Hyperspace

We all know that if a seaplane can reach takeoff speed, it has sufficient "lift" to rise above the surface of any sea or stream. Similarly, some investigators believe that if a starship could reach the speed of light, it could be lifted above the surface of our space-time plane. And just as seaplane flight above the water would eliminate sideways drift due to the currents of the stream, so starship travel above the x-ct space-time plane would eliminate sideways drift due to the currents of time. Thus, as a starship accelerates beyond the speed of light, we can visualise its path suddenly changing – now "climbing upwards in tau" instead of "sideways in time" as it begins its hyperspace jump above the x-ct plane.

During this jump, the starship will, figuratively speaking, soar over the space and time of the x-ct plane during most of its journey to its target star – with "unfoldment of tau" rather than "passage of time" occurring within the ship. Here, "unfoldment of tau" is entirely different from "passage of time": for time flows inexorably in one direction towards the future from the past, while tau must increase and then decrease in order for the ship to rise above and then return again to our familiar x-ct space-time plane.

Also, although the actual geometrical configuration of hyperspace is unknown, we must assume that its topology and curvature might cause some slight sideways starship drift in time during very long jumps above the x-ct plane. But just as light breezes in the air cause much less sideways drift than the strong currents of a swiftly moving stream, so the sideways drift of a starship in the time direction should be much less in hyperspace than upon the x-ct plane. Therefore, we can visualise the passage of time during a starship's



The Crab Nebula.

jump in hyperspace as being negligible compared to the much longer passage of time during its travel upon our x-ct space-time plane.

Finally, we might note that starship navigation in hyperspace is impossible unless its position and direction can be determined from on-board time and distance measurements and from each increment of tau that unfolds within the ship. And, of course, there must be some way of simultaneously correlating on-board measurements of distance, time, and tau in order that the starship execute a proper hyperspace jump above the x-ct space-time plane.

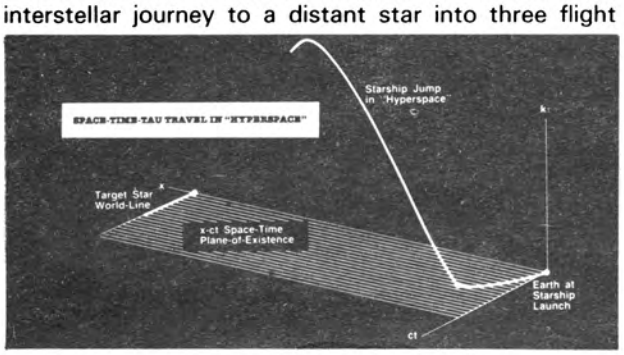
Starships' Paths in Space, Time and Hyperspace

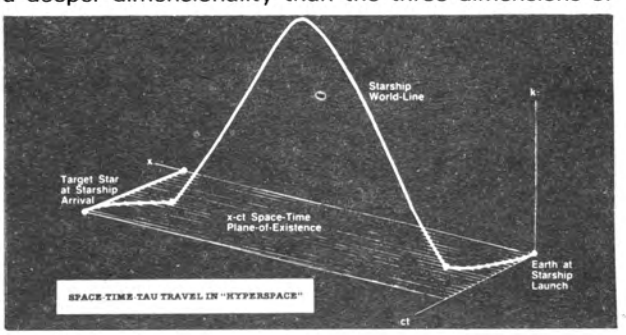
After reaching the apogee of its hyperspace jump, the starship's trajectory will curve downward in hyperspace until it touches down again upon the x-ct space-time plane. Then again, under the influence of the currents of time, the starship's path will be a curving line that is traced out upon the x-ct plane, a curving line that proceeds forward in space and sideways in time as the ship decelerates from light-velocity and finally reaches its target star.

It follows from all this that we can divide a starship's interstellar journey to a distant star into three flight segments. The first flight segment would involve starship acceleration in "normal" space and its disappearance when it reaches the speed of light. This flight segment can be symbolised by a curving line that is slowly traced out upon an x-ct space-time plane. The next flight segment would be the starship's hyperspace jump above our realm of space and time. This flight segment can be symbolised by a curving line, which almost instantly arches like a rainbow above the x-ct plane. The final flight segment would involve the starship's reappearance in "normal" space and its deceleration from light-velocity until arrival at its target star. This final segment can be symbolised by a curving line that is slowly traced out upon the x-ct space-time plane.

In summary, rapid transit to distant stars would involve starship acceleration to light-velocity and disappearance from human sight. Almost immediately, it would reappear billions of kilometres away in close proximity to its target star, but during those moments of disappearance, the starship would have "jumped" over so-called space and time – with its flight path arching like a rainbow over our x-ct space-time plane.

However, all this requires that our cosmos possess a deeper dimensionality than the three dimensions of





"normal" space and the one dimension of time – with this deeper dimensionality required to give starships room to soar over the space-time realm of existence of beings whose motion is slower than light with respect to Earth.

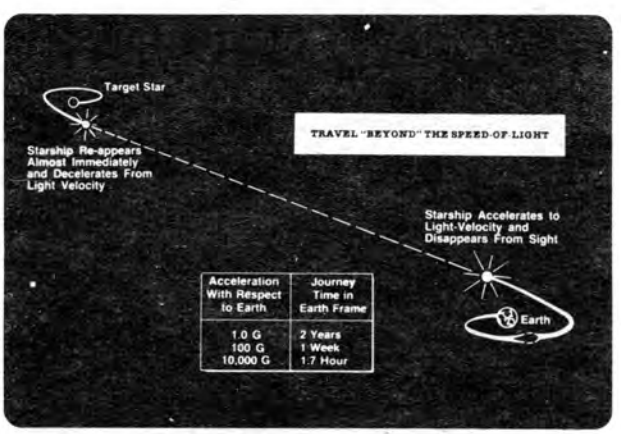
Unfortunately, we have no tangible evidence that our cosmos possesses such deeper dimensionality. Thus, if this deeper dimensionality does not exist, the stupendous gulfs of cosmic space may separate us forever from distant stars. But if it does indeed exist, there is surely hope that some spacefaring civilizations might learn to travel through it on round-trip journeys to even the farther stars.

Round-Trip Journeys to Distant Stars

Interestingly, if no appreciable time elapses during a starship's jump in hyperspace, the approximate time for it to accomplish any journey will be its time to accelerate to light-velocity and, after its hyperspace jump, its time to decelerate from light-velocity in the vicinity of its target star. Thus the duration of its interstellar journey will be influenced primarily by the time it takes to reach light-velocity and to decelerate from light-velocity – not by the amount of distance to its target star.

For example, if starship acceleration with respect to Earth could be maintained at a value equal to the acceleration due to gravity at the surface of the Earth (1.0 g), it would increase its speed by about 32 km per hour each second and reach light-velocity after 1 year had elapsed on Earth. If a comparable deceleration could be maintained after the hyperspace jump while the starship slowed down from light-velocity in the vicinity of the target star, another year of time would elapse on Earth. Thus the starship could reach or return from any interstellar destination in about 2 years of time as measured here on Earth. Furthermore, if the ship's acceleration and deceleration could be 100 times greater than Earth-gravity acceleration (100 g), it could reach or return from any interstellar destination in only about 1 week on Earth. If the ship's acceleration and deceleration could be 100 times greater than 100 g, its time to reach or return from any star would be only about 1 hour and 40 minutes, as measured here on Earth.

Thus, if starship acceleration and deceleration could be maintained at values comparable to Earth-gravity acceleration, round-trip journeys to distant stars could be accomplished in only about 4 years of time on Earth. If much higher levels of acceleration and deceleration could be maintained, such journeys could be accomplished in vanishingly small intervals of time – as measured on board the ship and on the Earth.



However, such levels of acceleration and deceleration would require the consumption of stupendous amounts of energy for enormous amounts of thrust, or, preferably some kind of "anti-gravity" technique, which would diminish starship inertia to values that would require only modest propulsive power and impose acceptable stresses and strains throughout the ship. Furthermore, as previously mentioned, a drastic transformation in starship state would have to occur in order for it to reach and exceed the speed of light.

Conclusions

Journeys to the most remote reaches of our Universe might be possible within the normal life-spans of starship crews if their ships could be rapidly accelerated to nearly the speed of light. But travelling to the most remote reaches of our cosmos and returning to Earth within the normal life-spans of earthbound beings would require rates of change of starship position that are, in effect, faster than the speed of light. To do this without violating current theories, such as Enstein's Special Relativity, would require that our cosmos possess a deeper dimensionality – a dimensionality that would give faster-than-light ships room to soar over the space and time of our so-called "physical world".

In summary, reaching and returning to Earth from the farther stars would require technological advances and extraordinary happenings within our cosmos that are beyond our current scientific knowledge and understanding. Thus, hope for overcoming the barriers of time and space rests not upon our current data base of technical knowledge, but rather upon our degree of faith in the possibilities of man. In this respect, a very high degree of faith in man's possibilities was expressed by Dr. Sanger at the Seventh International Astronautical Congress in Rome when he declared:

> ". . . It is by no means true that the (fixed) stars can be reached only after journeys of many generations in duration, during which numerous generations are born, grow to maturity and die again, until finally the distant great-grandchildren will perhaps reach the destination of the embarkers. Neither is it true that the foreign galaxies which are removed from us by hundreds of thousands of light years, are fundamentally unattainable because of our limited lifetime, and that nature has confined us to our small corner of the universe. No, we need not resign ourselves and meekly lay our hands in our lap. The infinite universe is sufficiently small that it remains accessible to the personal abilities of each one of us, up to its outermost reaches; everything is attainable to Man."

**A technical version of this article appears in the May 1983 JBIS issue under the title "Requirements for Rapid Transport to the Further Stars."*

"WE INTERRUPT OUR PROGRAMME"

CETI and the Panic Broadcast

By Curtis L. Peebles

In a quiet farm field, a battle was once fought. It pitted 7,000 men of a State Militia against a small scout unit, ending with the near total destruction of the militia. For those who heard the battle over the radio it was unforgettable. Yet, no monument marks the battle site of that foggy October night. The irony is, this famous battle never took place at all except in the terror-stricken minds of a radio audience. This non-event, however, has cast a shadow over man's view of his place in the Universe and his relationship with any other beings that might inhabit it.

Introduction

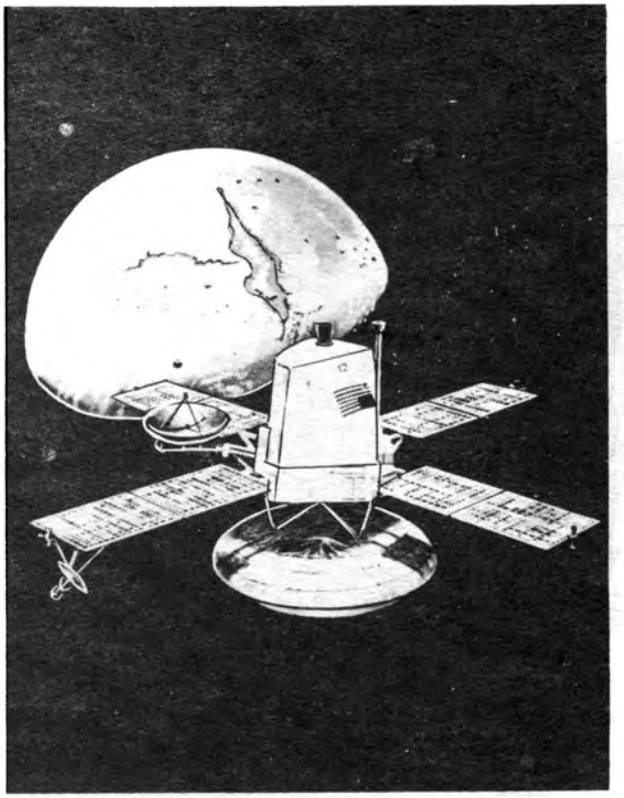
At 8:00 pm EST on Sunday, 30 October 1938 in the United States, Orson Welles' Mercury Theatre presented an adaptation of the science fiction classic "The War of the Worlds". The panic it unleashed is now part of American folklore and history.

Any discussion of contact with non-human intelligence must deal with questions on the aftermath of such a contact. Fears of a similar panic have been expressed involving, perhaps, the fall of major institutions or complete social paralysis [1].

Since the panic broadcast concerns our potential reaction to alien contact, it would be well to examine what brought about the panic.

The Broadcast

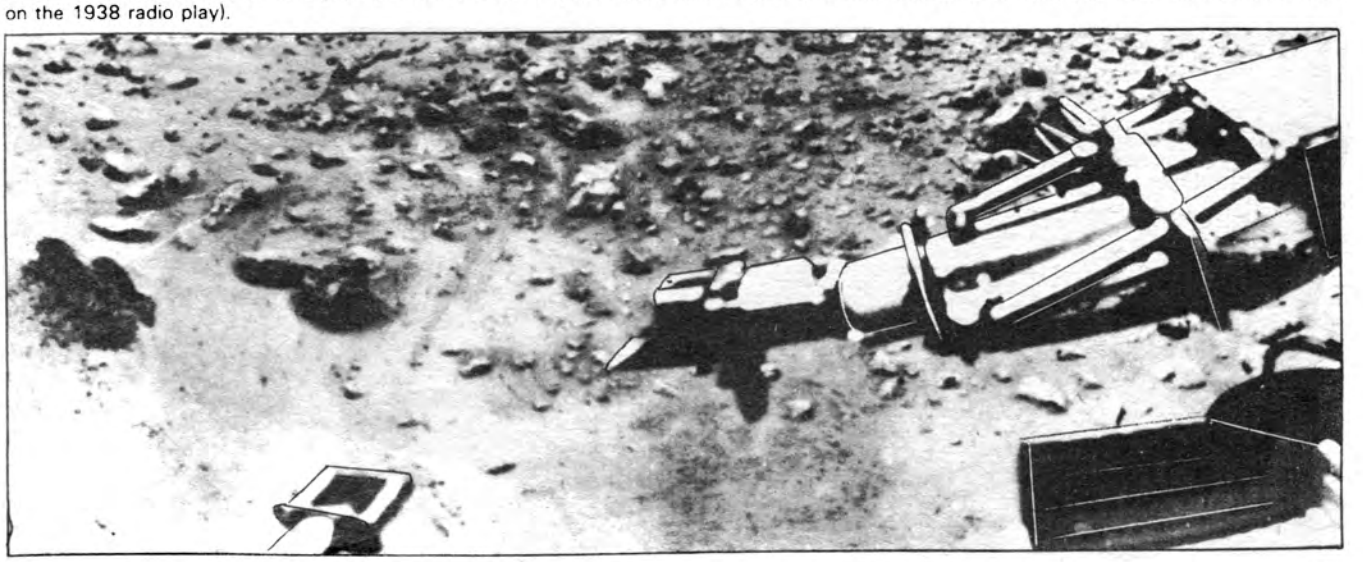
On that night 45 years ago there were 32 million families in the United States. Of these, 27.5 million owned radios. From surveys made the week before by the Crossley and Hooper radio rating services, it could be estimated that 34.7 per cent of the audience was listening to the "Chase and Sanborn Hour" variety show; the rival Mercury Theatre's share was only 3.6 per cent. The star of the Chase and Sanborn Hour, ventriloquist Edgar Bergen and his dummy Charlie McCarthy, dominated Sunday night, so much so that CBS was unable to find a sponsor for the Mercury Theatre. These percentages meant that, at the time the show began, about 1 million radios were tuned to the Orson Welles broadcast [2].

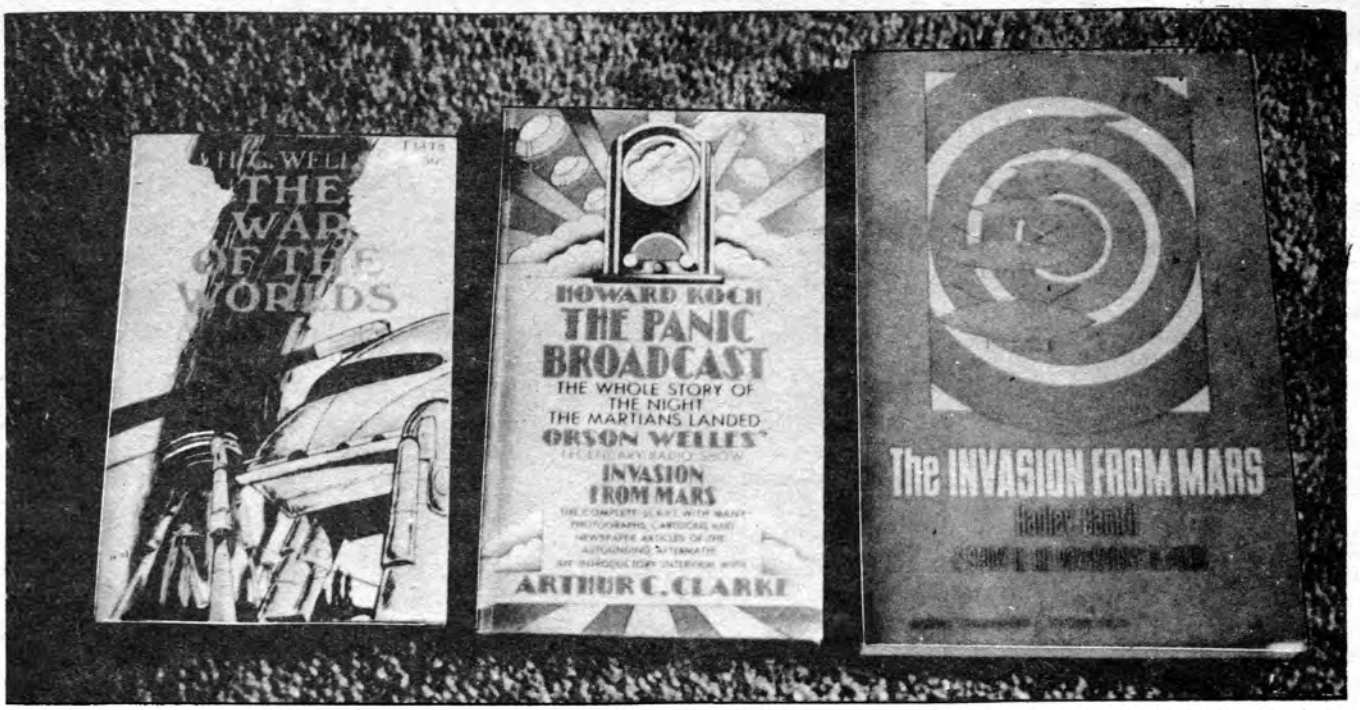


An Earthly invader of Mars. The Viking landers returned photos, weather data and chemical studies of the Martian soil in their six years of operation.

The script starts innocently enough. After a narrative introduction, which *clearly identifies* the programme as fictional, there comes a weather report and the beginning of a programme of dance music. It is quickly interrupted for a news bulletin about eruptions of incandescent gas occurring at regular intervals on Mars. The dance music is again interrupted by "Carl Phillips" interviewing "Professor Richard Pierson, a Princeton University astronomer". During the interview, Pierson is handed a report of a meteor landing outside Grovers Mill in New Jersey and requesting that he investigate. Phillips and Pierson go to "Wilmuth Farm" outside Grovers Mill. By a live radio hook-up Phillips describes

The Martian surface as viewed by the Viking lander: no cities, no people and no panic-stricken crowds terrified by its arrival. The data from the lander was relayed to Earth *via* equipment built at RCA's space centre located just down the road from Grovers Mill, New Jersey (mentioned on the 1938 radio play).





Three books on the panic. The first is H. G. Wells' *The War of the Worlds*. The broadcast was an adaptation of the novel substituting American locations and an updating to 1938. *War of the Worlds* is also the prototype of the "Hostile Alien" story. The second book is *The Panic Broadcast* by Howard Koch; he wrote the script for the Orson Welles programme. The book covers the story of his involvement and includes the complete script. The last is *The Invasion from Mars*, a study of the panic and the reasons for it.

a striking meteorite: a yellowish, white cylinder some 30 yards (27 m) across.

In the real world, it is 8.12 p.m. EST. Over at NBC, Bergen and McCarthy have finished their first routine and the commercial for Chase and Sanborn coffee begins. As it does, several million people switch to CBS. They hear Phillips describing the end of the cylinder unscrewing and then, in a horror-stricken voice, the scene as a Martian climbs out of the pit. It has tentacles for hands, a body the size of a bear with skinlike leather, two black eyes and a V-shaped mouth. As America listens, the Martians turn a heat-ray on the crowd. Wood buildings and cars burst into flames; Phillips' broadcast ends with a sudden silence.

The cylinder is surrounded by 7,000 men of the New Jersey Militia. Then, a Martian fighting machine rears out of the pit; the militia is wiped out, as is an artillery unit and a flight of Army bombers. The "Secretary of the Interior" addresses the US in an attempt to calm the population. By about 8.45, New York City is overrun and the nation is in a very real panic.

The rest of the show was set many weeks later and dealt with the Martians' defeat by Earthly germs. It played no part in the panic.

Aftermath

A two year study of the panic was undertaken by Professor Hadley Cantril of Princeton University, with the results being published in 1940. He found that, of the estimated 6 million who heard the programme, about one million were disturbed or frightened by it. A number of reasons was discovered. Firstly, the script was excellent and Orson Welles' production was a technical masterpiece. Secondly, the format was important. To give a measure of authenticity to the incredible events, the first half used news flashes, live remote broadcasts, interviews, special bulletins and announcers relaying information. These were all common features of radio news in the 1930's. Used as dramatic devices, they convinced the audience that it was real. Through them, the listeners became unwilling witnesses as the Martians wreaked havoc. It was quite literally the first war "fought" in America's living rooms.

As the action progressed, the characters became steadily more amazed, baffled, fearful and finally terrified. Thus the fictional characters and the real audience shared the same emotions. An atmosphere of belief was created; it sounded "right". Having long been conditioned to radio news procedures, many simply automatically presumed it was true. As one listener put it "I just naturally thought it was real. Why shouldn't I"?

Also, numerous real place names were used: Grovers Mill, Trenton, Newark, the Palisades, Times Square and the Holland Tunnel are a few examples. These factors were important because between 40 and 60 per cent of the audience tuned in after the show's introduction and it was found that a higher percentage of those who believed it was true was among this group. Those who listened from the beginning thought that genuine news bulletins were interrupting a fictional play, or they had simply not been listening. The reason for such a high percentage was because of people who switched from Charlie McCarthy and to those who had been called in by friends or relatives to listen.

Heightened realism was added by the high positions of some of the characters. Numerous astronomers, a State Militia General, Vice-President of the Red Cross, Captain of the Army Signal Corp and "the Secretary of the Interior", the latter sounding like the then President Roosevelt, were mentioned. The study recorded numerous cases where creditability was heightened by the prestige of the speakers. If they said something, then it must be true.

The study also found that the most important factor in determining who would panic was education. Only 28 per cent of those with a college education believed the invasion was true, as opposed to 46 per cent with only a grammar school education. This proved to be more important than a person's economic situation. An education apparently made it more likely that a person would find the broadcast too incredible or have some specific knowledge to realise that it was a play.

This includes recognising Welles' voice, being familiar with the story, or simply realising that events were moving too fast to be real (the State Militia was destroyed in less than three seconds). It also depended on what part of the play was heard (some parts did not mention Martians). The critical ability, to separate fact from fiction, could be overwhelmed by factors such as insecurity, worry, lack of self-confidence, etc.

Some people, once convinced the bulletins were true, were able to mentally adjust the impossible into something believable. Any inconsistencies were rationalised as confusion on the part of the announcer.

Panic is also contagious; it was spread by people urging others to listen. Some 75 per cent of those who listened on the advice of others believed it was news. Their fear became evidence that the broadcast was true.

The panic had a geographical aspect. Over 60 per cent of the listeners near the "landing site" who thought it real, panicked; this reduced as one moved west. The implication is that the farther one was from the "battle", the lower the level of concern. The exception was in the far west, where the level of concern matched that of the east. The study could not determine a reason except that the cylinders were landing all over. Although not in the study itself, a possible reason was that many people in the west, especially California, had moved from the east and, therefore, may have had relatives in the affected area.

The study found that the idea of life on Mars was well established – it was 60 years since the "discovery" of the Martian canals. At least one person interviewed had heard of rockets and their use in interplanetary travel (remember, this was in the 1930's).

External Factors

The listening environment goes far beyond the quality of the script or the circumstances of the listener. The world situation in late October 1938 must be considered.

The Great Depression had started in 1929 and the intervening years had changed basic assumptions and social norms. The economic dislocation had generated unrest, frustration and dissatisfaction. It was not unusual for some people to have been unemployed for literally years. Also, people found themselves in an increasingly complex world. Modern developments were not understood, science was a mystery.

Foremost, however, in the study's view was the Czechoslovakian crisis of September 1938 – only a month before the broadcast and covered extensively by NBC and CBS. There were almost constant interruptions for news bulletins, live reports from European capitals and interviews – the very same format, four weeks after the Munich Pact, that the War of the Worlds' broadcast would use with such devastating results. The nation's attention was riveted on Europe for several weeks to the exclusion of all else. A storm, which hit the Eastern seaboard of the United States and caused major damage, went almost unnoticed. Surveys of the time indicate that the vast majority of Americans believed they would be drawn into a general European war. The two oceans, upon which American isolationism depended, did not seem so wide anymore. War, invasion and the destruction that went with it seemed near.

Much of the blame for the panic would be tracked to public jitters caused by Munich [3, 4].

Other Contacts

The panic is relevant even 45 years later. What insight does it give to the question of the public reaction to CETI (Communication with Extraterrestrial Intelligence)? Is a prediction of a similar panic valid? The Princeton study implies that it would not be a simple reaction. The panic in 1938 came about for a variety of reasons – the quality of the script, social factors and the lingering effect of the Munich crisis. One must also remember the violent nature of the contact. The Martians, without provocation, opened fire on the crowd at the landing site. They went on to sweep aside any opposition with brutal ease. In reading accounts of the listeners, it would seem that this fear of destruction was more responsible for the panic than any inherent fear of Martians. In fact, over 25 per cent of those who panicked believed that the invaders were either German or Japanese. Some did not hear the part dealing with the Martians or some believed it was an effort by the attackers to hide their identity.

That a fear of war was responsible for the panic was supported by a similar, but much smaller, reaction in August 1977. A Swiss radio play used news flashes interrupting music and local programmes to describe heavy fighting on the German border ending with the use of nuclear weapons. About 40 calls were received during the programme and more afterwards. The total audience was about 200,000 – much smaller than for "The War of the Worlds"[5].

One difficulty in predicting the public reaction to aliens is the wide variety of ways in which contact could take place. It could range from the reception of a radio or other signal to that fine old classic the landing on the White House lawn. A major variable would be the degree of personal contact. A simple example would be the discovery of an artifact such as a container left on the Moon before there was life on Earth. This would be proof that extraterrestrial life existed, yet there would be little information about their nature, society or technology. They could have even long since become extinct. One would be hard pressed to find grounds for panic in this.

The reception of a signal would provide more information, yet we would be separated by many light years. A safe enough distance it would seem. The only scenario which seems to carry the potential for a panic reaction would be direct personal contact between humans and extraterrestrials. Only here would be the potential for a "War of the Worlds" confrontation. This is also the least likely scenario.

Short of actual hostilities, the primary reaction would probably be one of curiosity. Some 500,000 people turned up to watch the fourth Space Shuttle landing. Although the potential for danger might keep some away, the desire to witness a historical event such as an alien landing would generate similar crowds.

Although some thought should be given to how to break the news by those searching for extraterrestrial signals, the events of that October night need not bar the undertaking.

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REMOTE SENSING IN INDIA

By Radhakrishna Rao

Much of the motivation behind the Indian space programme has been to raise the living standards of the country's enormous population. A large part of that programme has been designed to enable the continent's vast resources to be located and exploited.

Introduction

Remote sensing, a powerful means of resource mapping, is being harnessed by India to accelerate the country's development. Because of its vast size and large unexplored natural wealth, India has found a means in remote sensing for collecting data on renewable and "once-only" resources.

Since India shot onto the space map in November 1963 with the launch of a US-built rocket from the small fishing village of Thumba in Kerala, it has enjoyed an eminent position in the third world in using remote sensing. The Indian Space Research Organisation (ISRO) is the major focus of such activities. Through its Space Applications Centre and the National Remote Sensing Agency, ISRO has been actively engaged in carrying out a variety of projects.

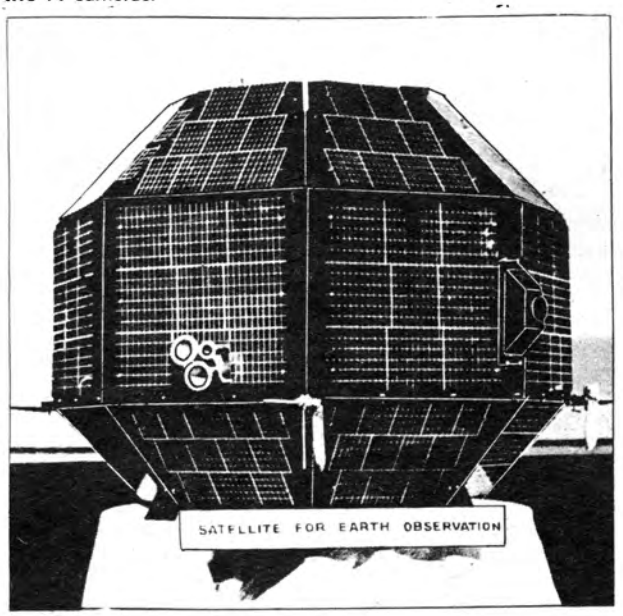
It was a careful study and analysis of images returned by the US Earth observation satellite, Landsat, that took ISRO into the remote sensing field. Encouraged by Landsat's success in identifying and monitoring global resources, ISRO carried out India's first remote sensing experiment in 1970 using a helicopter. This modest experiment was aimed at detecting coconut plantations affected by a blight epidemic.

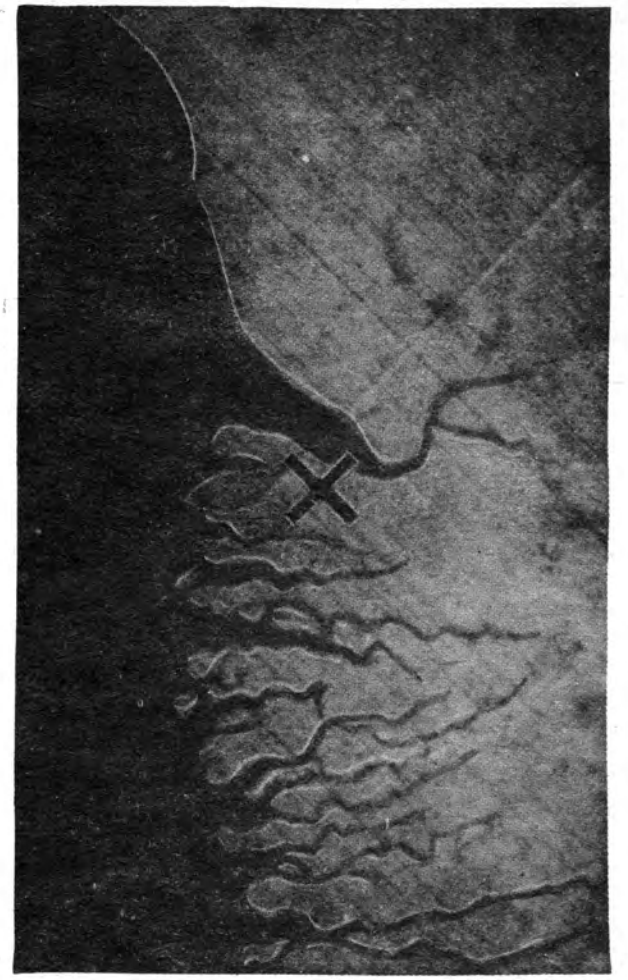
A number of smaller surveys followed, mainly directed towards studying the agricultural and landscape features in various parts of the country.

ARISE

In 1974 India's remote sensing activities took on an important new dimension with the success of project

The Indian-built Bhaskhara 1 satellite was launched in 1979 carrying two TV cameras.





An image of the Bengal coast taken on 30 November 1981 by the Bhaskara 2 satellite, launched by the Soviet Union for India.

ARISE (Agricultural Resources Inventory Survey Experiment) which was designed to provide data on the nature and extent of agricultural yields.

Agriculture is the economy's backbone and the successful prediction of crop yields provides a firm base for national planning. For the first time, ARISE paved the way for establishing a system of collecting timely and accurate data on yields. It also showed that different crops could easily be separated and identified by air-borne sensors.

Under ARISE, agricultural fields in the Anantpur district of Andhra Pradesh and the Patiala district of the Punjab were extensively surveyed by aircraft-mounted Hasselblad cameras using special film-filter combinations. It was very much a learning experience:

1. Establishing for the first time a capability for carrying out large aerial surveys;
2. Setting up a colour infrared processing facility;
3. Evolving the methodology of computer processing of multiband aerial images.

In addition to its own surveys for agricultural and land-use studies, India has also been using Landsat data to meet the needs of ISRO government agencies and research institutions. An Earth station receives data from satellites of the Tiros, NOAA and Landsat series.

Information from these satellites has been used to locate sites in Andhra Pradesh for hydroelectric schemes, monitor water pollution and crop yield patterns in Karnataka, study oil spills off the Bombay coast and predict the extent of snow melting affecting rivers originating in the Himalayas.

India has also built a sound base for developing the hardware for remote sensing experiments. A five-channel multi-spectral scanner, an infrared scanner, a side-looking air-borne radar and a synthetic radar developed by ISRO have all given excellent results. Facilities have also been set up for photo-interpretation and computer-based analysis systems.

The remote sensing programme reached a major milestone in July 1979 with the successful launch of the home-built Bhaskara 1 from the Soviet Union. The polyhedral 444 kg satellite was developed from the flight spare model of the first Indian satellite, Aryabhata, launched in 1975.

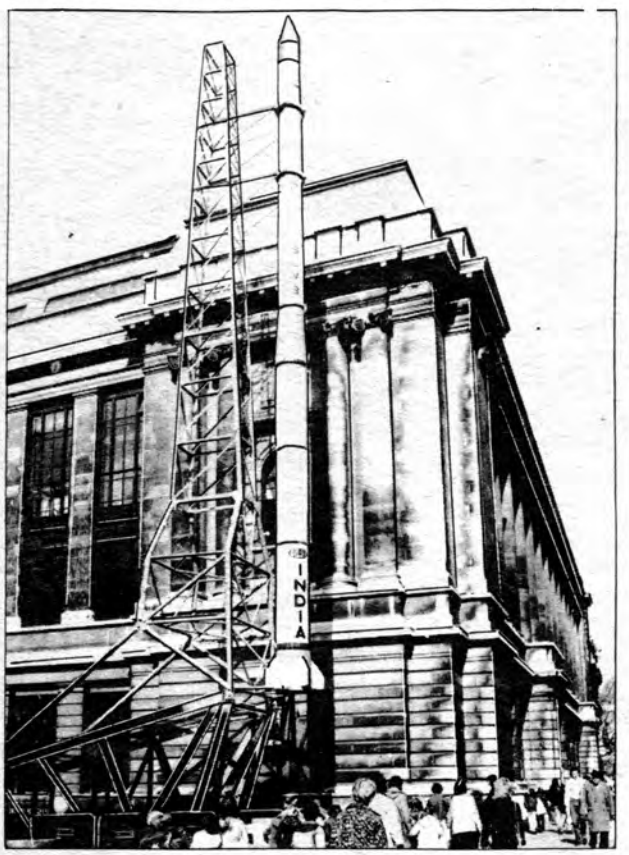
For Earth observation studies Bhaskara 1 carried two TV cameras working in the 0.54–0.65 and 0.75–0.85 micron spectral bands and a microwave radiometer operating at 99.35 GHz and 22.235 GHz. The main aim was to gain experience in the collection, processing, analysis and use of data in hydrology, forestry and geology (using the TV cameras), and to study the ocean surface and atmospheric moisture using the microwave radiometer.

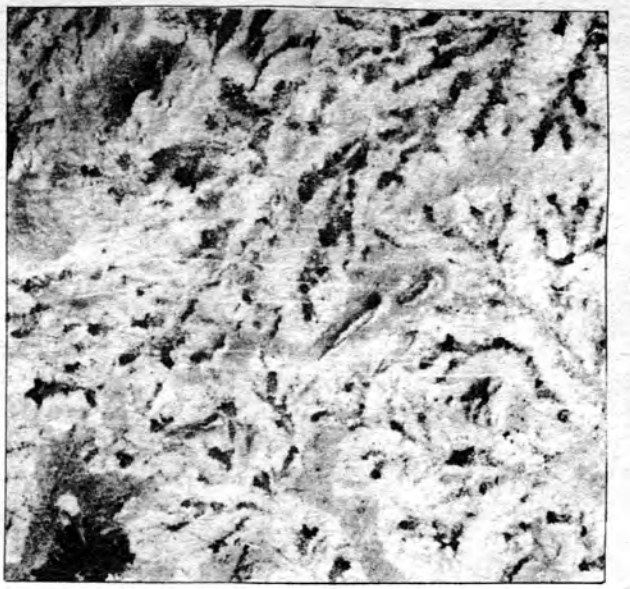
The TV cameras have been used for studying the melting of snow in the Himalayas, the flooding of rivers in northern India, the dynamics of desertification in Rajasthan and mineral resources in Gujarat. The microwave radiometer has helped in the estimation of rainfall over the seas surrounding India and of water vapour and liquid water content in the atmosphere.

The 40 kg Rohini satellite launched from Indian soil in May 1980 on top of a home-built SLV-3 rocket carried a solid state Earth imaging landmarker camera (based on the charge coupled device) for remote sensing studies. Though the satellite was planned to survive for 40 days it re-entered and burnt up after only nine, but at least it proved the camera for coarse geographic observations.

Bhaskara 2, an improved version of the family, was launched in 1981 by the Soviet Union. It has proved valuable in meteorology, vegetation surveys and other fields. Its images have been used in preparing land-cover and land-use maps of parts of West Bengal and the microwave sensor helped to determine atmospheric water vapour, rainfall rates and sea surface winds.

The SLV-3 rocket provided India with its initial launch capability.





An image of Tiruvannamalai in S. India obtained in September 1979 by a Multi Spectral Scanner flown aboard an aircraft.

Based on the expertise acquired through the Bhaskara projects, India is now developing a semi-operational three-axis stabilised Indian Remote Sensing (IRS) satellite for launch in 1986. Essentially, IRS marks the combining of technologies that have gone into building the Bhaskaras and the three-axis stabilised APPLE (experimental communications) satellite launched by Europe's Ariane in June 1981.

Meanwhile, ISRO has entered into an agreement with the Soviet Union to launch an IRS mission which will put an 800 kg satellite into a polar Sun-synchronous orbit from where it can map out a particular stretch of Earth every 21 days. The IRS will be a forerunner of a series of fully fledged Indian remote sensing satellites planned for launch towards the close of the decade by the Indian-built Polar Satellite Launch Vehicle (PSLV).

IRS will carry three Linear Imaging Self-Scanning Sensors; – one with a 70 m field of view, the others with 35 m fields. The mission has three main aims:

1. Acquiring expertise in three-axis stabilised operational remote sensing satellites;
2. Operating ground systems for data reception, recording, processing and generation of data for the benefit of users;
3. Using the data for survey and management of resources in agriculture, geology and hydrology in association with user agencies.

IRS's successor is expected to observe in new wavelength regions such as middle and thermal infrared, with an increased number of spectral channels. ISRO is also planning the parallel development of satellites with active microwave payloads.

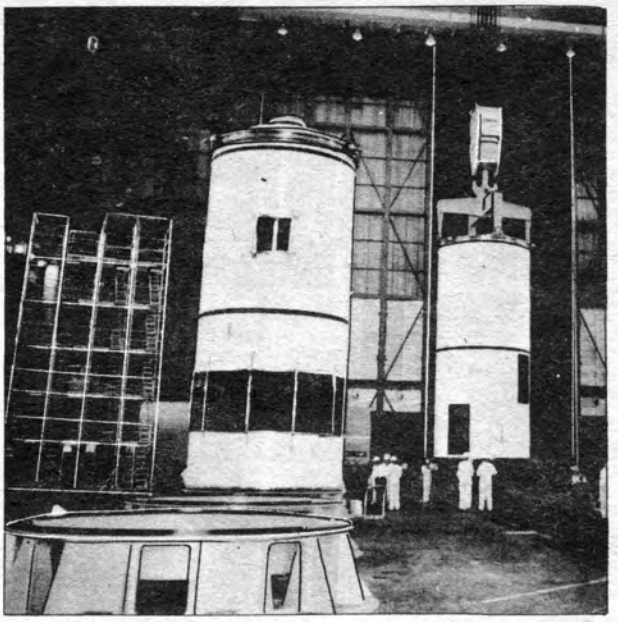
Conclusions

With the launching of IRS in 1986 the Indian Remote Sensing Programme will really have come of age. Its success will vindicate the basic philosophy of concentrating on the exploitation of space technology for resources mapping and management.

HANDLING THE SHUTTLE'S BOOSTERS

By Gerald L. Borrowman

The Solid Rocket Boosters provide a spectacular sight as the Space Shuttle leaves the pad. But handling them can be a problem — NASA is now bringing a new facility into operation at the Kennedy Space Center to prepare the basic components of these motors for flight.



Preparing to stock an SRB segment on the launch platform in the Vehicle Assembly Building.

Introduction

Since the Space Shuttle is intended to be an economical reusable spacecraft, the reduction in time spent on the ground between missions is important. The construction of new Solid Rocket Booster processing and storage facilities at the Kennedy Space Center is a two-stage undertaking that will help to streamline Shuttle operations. Phase I includes offices, shops and mechanical/electrical rooms, and two eight-segment storage buildings. Building began on 21 May 1982, with a target of operation by February 1984.

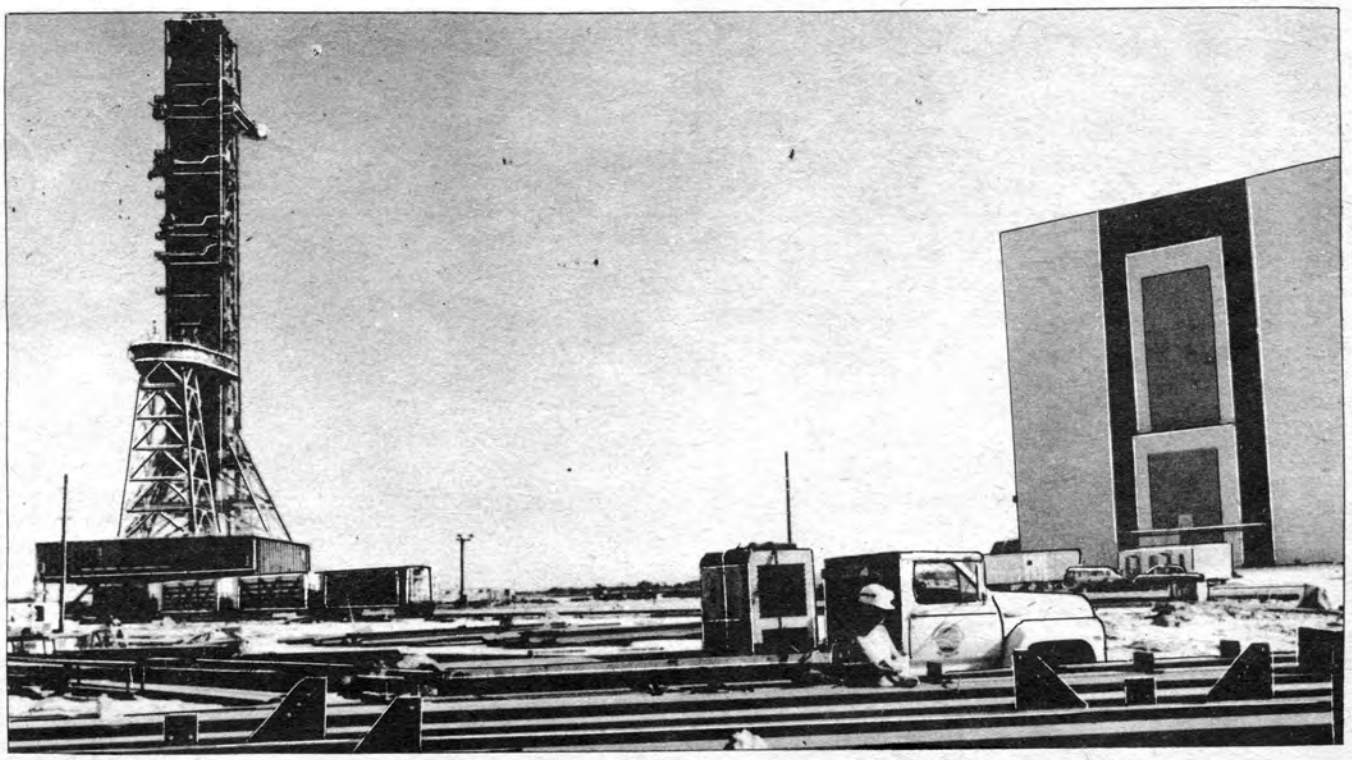
Phase II, which provides for facilities to allow KSC to handle 40 shuttle launches per year, includes a second main facility and support buildings for inspection, rotation and processing of all live SRB segments. The three Phase II storage buildings, when combined with those of Phase I, will allow five pairs of boosters to be held in readiness.

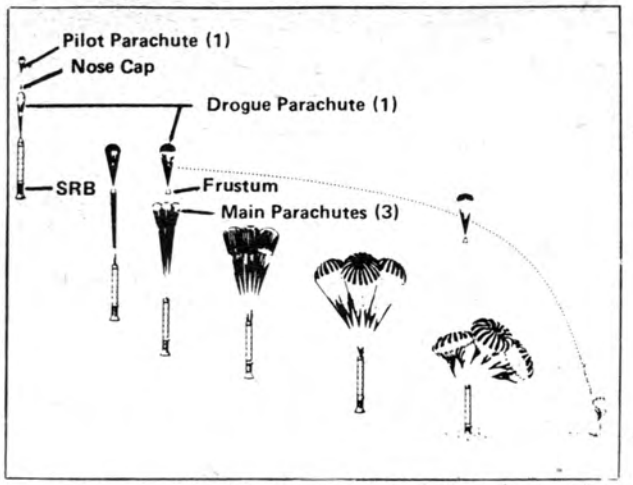
Processing the Booster Segments

The SRB segments are shipped by rail from their manufacturers in Utah to KSC, where they can be stored until required. They arrive at the new Rotating/Processing Facility, a 64 × 27 m complex built of steel to resist winds of hurricane force and loads from the two 200-tonne bridge cranes. Here the segments are inspected; used motors can also be loaded on the special rail cars for the journey back to Utah for reuse.

Live segments (i.e. those with propellant) are positioned beneath one of the cranes, hand slings are attached and the railcar cover is removed. The segment is inspected horizontally before the cranes hoist and rotate it to the vertical. One crane is released and the other places the segment over the inspection stand where the aft handling ring is removed. Next, the

Site of the new booster processing facility. At right is the VAB, where the boosters, external tank and Orbiter are mated; at left is the old Apollo/Skylab launch platform.





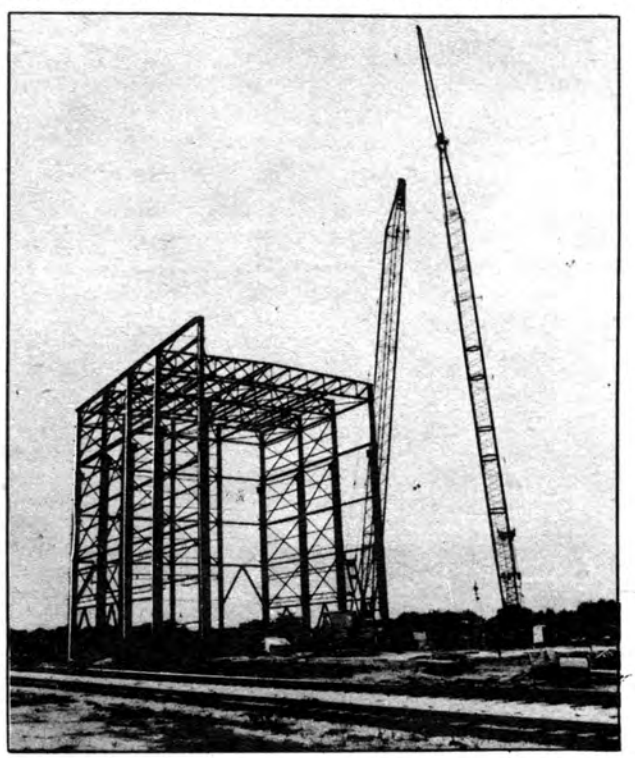
segment is moved on to a pallet on a special transporter. Moveable platforms allow technicians to remove the forward handling ring and the segment can then be enclosed by soft covers.

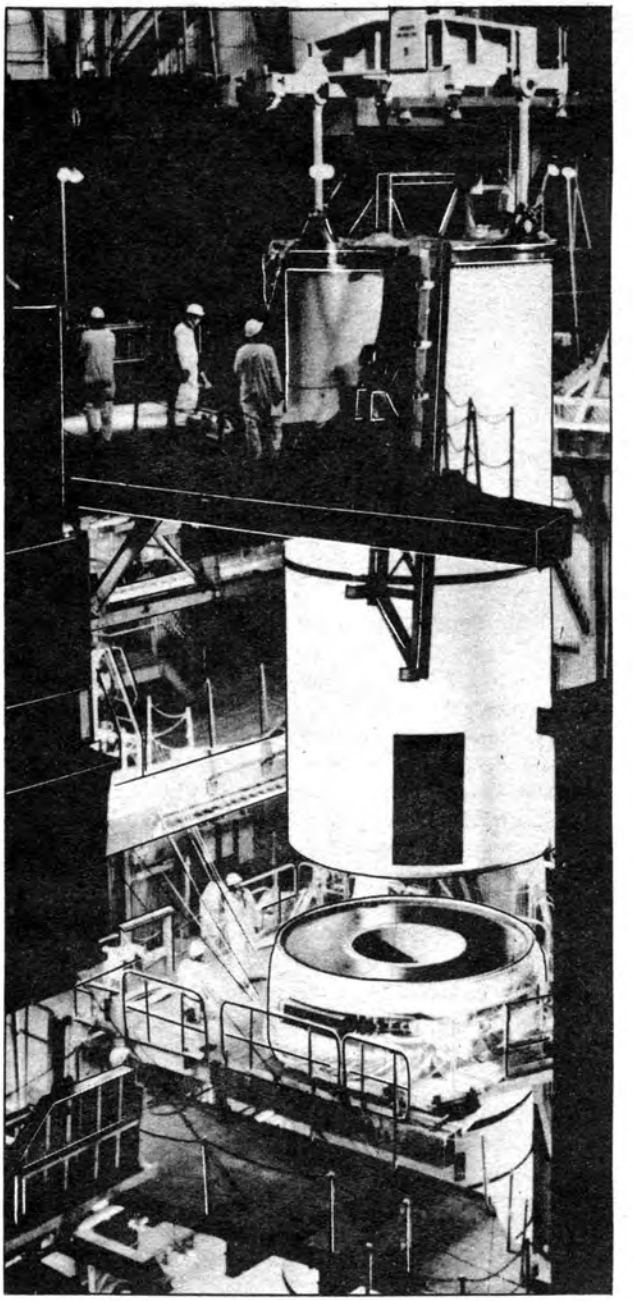
Aft skirts (the conical bottom sections of the boosters) are brought in ready from the refurbishment facility in the Vehicle Assembly Building. The aft booster segment, with the rocket nozzle, is mated with the skirt, and hydraulic, nozzle alignment and other tests are performed. Handling rings then allow the completed unit to be taken into storage or moved into the VAB for more work.

So far, this work has been carried out in the VAB. When the aft segment workstands, presently in the VAB's High Bay 2, are installed in the new processing facility the basic design will be retained but existing stairs, flip-down platforms and platform floor levels extending to existing VAB floors and lifts will be removed. Modified stairs, etc. will be added.

The processing facility will house all SRB activities, except for the final stacking of segments on the mobile launch platform, which is done in High Bays 1 and 3 of the VAB.

Erecting the frame for part of the new SRB processing facility.





Mating two SRB segments in the VAB; note the ring of solid propellant. Each booster carries four main segments.

All illustrations NASA

Safety

During the last five years evidence has accumulated that indicates the processing of SRB segments in the VAB is more of a safety hazard than originally envisaged. Studies reveal that ignition of an SRB segment in the VAB could cause deaths and major damage to Shuttle flight hardware.

This danger was highlighted by an incident in 1979 when a 2 m diameter segment was inadvertently ignited at United Technologies Corp., the manufacturers. It was decided to remove as much processing and storage from the VAB as possible.

The construction project provides two new storage facilities for up to 16 segments, including two segments in the aft buildup stands. The VAB presently has in-process storage for eight, including working storage in the aft segment workstands and temporary positions on the floor of High Bay 4. This extra space will help Shuttle managers to keep some capacity in reserve.

HOME GROWN IS BEST

Occupants of future space stations could survive much more cheaply by growing their own food. That is a conclusion of a study conducted by Boeing Aerospace for NASA's Controlled Ecological Life Support System (CELSS) programme which looked into the recycling needs of such future space missions.

Astronauts have always carried their own food and oxygen supplies and have stored waste. But weight penalties and transportation costs for longer missions and larger crews could prohibit storing or resupply in the future. At some point, recycling refuse into consumable supplies will become economically attractive..

Boeing researchers looked at NASA planning forecasts for the next 50 years and examined six typical missions to determine which of them could benefit from recycling. They include:

A Low Earth Orbit (LEO), low inclination space station;
A LEO, high inclination space station;
A military command post in an orbit at about 212,000 km altitude;
A Lunar Base;
An Asteroid Base;
A Mars Surface Exploration mission.

For the study, weight and cost of storage and resupply were compared to weight and cost of equipment needed to grow food and recycle waste. Three systems were compared:

(a) All food provided by storage and resupply; water and oxygen recycled by physical-chemical processes.
(b) Plant growth to contribute 50 per cent of the diet, with 50 per cent supplied as packaged food; water and oxygen recycled by both physical-chemical and biological processes.
(c) Plant growth to contribute 97 per cent of the diet, a vegetarian diet, with the remaining three per cent supplied by vitamins such as B-12, seasonings and other condiments; water and oxygen recycled by biological processes.

Although the study indicated recycling would save money on all long-duration missions, it was found to be impractical for the Mars mission because of its relatively short duration. The most effective use of recycling was the Low Earth Orbit low inclination space station (the earliest of the missions planned) – this would be a permanently occupied station at an inclination of 28.5 degrees.

The study envisaged this station as a four-to-12-man centre responsible for assembly and construction of complex spacecraft, service and basing of upper stages and service of free-flying satellites. For a station operating for longer than six years, regenerating 50 per cent of the diet is less costly than resupplying the required food.

If the station operates for more than eight years, producing 97 per cent of the diet is more economical than resupplying an equivalent amount of food. A conservative estimate indicates this system would save at least $68 million over a 15-year station lifetime.

Other missions studied and their results are:

• Low Earth Orbit, high inclination: a four-man, scientific station to investigate various aspects of the Earth and Sun in a Sun-synchronous orbit at an inclination of about 97 degrees. The system using plants to contribute 50 per cent of the food needs would become cost-effective at 5½ years; contributing 97 per cent would be best to use for seven years, compared to total resupply.

• A command post in a 212,000 km circular orbit, supporting four to 24 people with infrequent resupply would find a 50 per cent system to be cost effective after about 10 years.

By 15 years, the potential cost saving for a 50 per cent system amounts to $30 million. A 97 per cent system would be cost-effective at about 13 years, when compared to the cost of resupplying the post.

• Lunar Base: on the lunar surface with 12 to 48 people, primarily concerned with transporting soil to lunar orbit for use in construction and manufacturing missions would find a 50 per cent system cost-effective at 5½ years and a 97 per cent at seven years, as compared to the cost of resupply.

• Asteroid Base: a mining mission to extract minerals from the asteroid belt, using as many as 5,000 people, would use the 97 per cent system to show an economic break-even point at about 2½ years (about the time of the first resupply and rotation cycle).

• Mars Surface Exploration: a mission involving extensive travel time (about 1,000 days) and a manning commitment of eight on Mars would call for all food to be stored and/or resupplied. A 50 per cent system would not pay off for five years and a 97 per cent system would not be cost-effective for nine years. These extended durations are outside the scope of this mission.

SATELLITE RADIO TRACKING FOR THE AMATEUR

By Curtis Peebles

Readily available unmodified short wave receiver equipment can be used to receive radio signals from orbiting satellites. The Kettering group in Britain, for example, has, for two decades, been tracking Soviet satellites and their work has provided much information about the Soviet space programme. They started as a school group and their greatest triumph was the discovery of the Plesetsk launch site. This article explains how an individual or group, with limited knowledge and experience, can get started with short wave equipment. It explains what features their equipment should have, what type of antenna is suitable and how to tell a satellite signal from that of a ground source.

Hardware

The most important requirement for the would-be satellite tracker is patience. There will be frustrations and one should be prepared. In terms of equipment, the short wave receiver must be able to pick up Single Side Band signals and have a Beat Frequency Oscillator. This is indicated by a switch or knob labelled "SSB" or "CW" (for continuous wave). Not all short wave receivers are so equipped. In particular, the combination AM, FM, MB and short wave sets rarely have this feature. For satellite reception signals fall between 15 and 30 MHz but it is useful to have a wider band width set, say 540 KHz (just below the standard broadcast band) to 30 MHz.

One should be familiar with the receiver and its features. A digital frequency read-out is nice to have since it allows very precise tuning. It will, however, add to the cost and is standard equipment only on more modern sets. It is available as an add on feature for older sets. The author's set is a Realistic DX-302.

An antenna is required for proper reception. Fortunately, there is no need to build a Goldstone in your back yard; a simple wire antenna is all that is necessary. It should be from 30 to 50 ft (10–15 m) in length. Its placement will depend on one's location and circumstances. As a given rule, it should be placed as high as possible. One good method is to string the antenna from the house to a tree; another would be to place it on the roof. The author uses an L-shaped antenna along the eaves of the roof. The lead-in wire is attached at the right angle. Those who share their building with others might have problems: much will depend on the tolerance and space mindedness of their landlord or tenants' association. If the building is sufficiently tall, the antenna may be dropped out of a window; it should be reeled up after use. In any event, the antenna must *never* go either over or under an electrical wire because of the risks of shocks.

There are two additional pieces of useful auxiliary equipment. The first is a tape recorder. The signals will reveal more with multiple listenings and a library of tapes from various satellites can be built up. Many sets have a tape recorder connector point. The other add-on is an accurate clock for recording the time. Frequency, strength and duration of a signal can give a general idea of when the satellite is next due. Notes of this and other pertinent information should be kept in a notebook or on the tape recording.

Listening In

Signals from an orbiting satellite differ from those of a ground transmitter. A satellite signal is, generally only detectable when the satellite is above the horizon. (For all but this brief period there will only be the hiss of static – a sound like frying bacon. Unless one is willing to spend long hours waiting in anticipation, orbit information is a must!) The most important difference, however, is in the Doppler shift. The orbital motion of a satellite causes the received frequency of the radio signal to change. As the satellite moves toward the listener, the frequency will be higher. At the satellite's closest point, the frequency will be at its listed value. As it moves away, the frequency will be lower. Normally, this amounts to about 2 KHz either side of the central frequency for a low orbit satellite passing directly over. The frequency of a ground source of course does not show this change.

Tuning In

At acquisition of signal, the transmission emerges from the background static. Because the signal frequency is variable, it is best to have the Selectivity

The author's receiver. Here it is set for 15.008 MHz; the digital readout makes tuning much easier

switch to "wide". Once the signal has been acquired, it may be switched to narrow. As the satellite nears, the signal grows stronger. (In a pass where the satellite goes directly overhead, the signal will be very loud and clear.) The signals are crisp with none of the fuzziness of distant sources. One continually re-tunes the set downwards to compensate for the Doppler shift. As the pass continues, the signal will grow weaker and finally become lost in the static again. The downward trend in frequency during a pass is very distinctive.

The total duration of a pass is about 10 to 20 minutes although atmospheric conditions can extend this. Duration is dependent on the satellite orbit and its ground track. A transmitter aboard a satellite covers a circular area on the ground (allowing for local terrain). If the ground station is on the edge of the circular area, the duration of the pass will be short, the signals never become very strong and the Doppler shift will be minimal. As one gets closer to the centre line of the ground track, the duration increases, the signal is stronger and the Doppler shift becomes more pronounced.

Telemetry signals are a series of tones of differing lengths. It is not the "dit" and "dah" of Morse Code. But be warned there are other signals which can sound like telemetry. Because the set is switched to receive SSB signals, transmission using AM can be so distorted as to be unrecognisable. A particular problem for American listeners is found around 15.0 and 20.0 MHz where WWV time signals are transmitted using AM mode. The tones that signal the seconds and minute marks, and the announcer's voice, can both interfere and lure the unsuspecting. The way to detect such false signals is to retune the set and/or switch to AM mode. Using this procedure, one promising signal turned out to be a radio announcer speaking in an Oriental language! Another clue, again, is Doppler shift. If it is not present, then the signal is from a ground source.

Soviet Satellites

Soviet satellites transmit their telemetry and beacon signals at short wave frequencies between 15 and 30 MHz; generally, in the Upper Side Band mode – and they transmit continuously. Neither is true of US satellites and manned missions. The Apollo's prime voice channel was 2287.5 MHz; this is the famous "S band". Equipment to receive such frequencies is both difficult and expensive to acquire. US satellites, also, transmit only when in range of a ground station.

As a satellite tumbles in orbit, the polarization of its radio signals change with respect to Earth. For the ground listener, this can cause periodic fadeouts.

Just as the orbital characteristics of a Soviet satellite can give a clue to its function, so can the frequencies it uses. The civilian Salyut space stations use 15.008 MHz; military Salyuts use, on the other hand, 19.944 MHz. Soviet reconnaissance satellites use a variety of similar frequencies: 19.994, 19.995, 19.989 and 19.990 MHz. It was this similarity that gave the first clue to the military Salyuts' nature. Soyuz spacecraft use 20.008. The Cosmos 929/1267 space station modules used several frequencies: 15.008, 18.008, 18.060, 19.954 and 20.008 MHz. The 19.954 MHz telemetry signals were most distinctive, sounding rather like a bird call.

A final type of satellite was built specifically by the Soviets for amateur listening and use: the RS satellites. Like the US Oscars, they are satellite relays used by amateur radio "hams". The downlink signals retransmitted by the satellites are on 29.330, 29.340, 29.402, 29.410 and 29.460 MHz. One can, also, sweep between 29.3 and 29.5 MHz. The signals from the RS satellites are regular Morse Code.

Soviet voice communication is more difficult to acquire. It requires a completely different set of equipment. The receiver must be able to pick up the amateur 2 m band. The prime voice channel is 143.625 MHz with FM mode and a 35 kHz deviation. The set may require modifications as most have a band width too narrow to accommodate such a large deviation. Also, the Soyuz's transmitter has an output of only 4 watts so preamplification may be necessary. For these reasons, voice transmissions may be best left until one has more experience.

Soviet Frequencies

MHz	*Use*
15.008	*Salyut Telemetry*
17.365	*Unmanned satellite beacons*
18.000	*Satellite beacons & telemetry*
19.150, 19.300, 19.994	*Soviet reconnaissance satellites*
19.995, 19.989, 19.990	
19.944	*Military Salyut telemetry*
19.954	*Space station module telemetry*
19.995	*Soyuz and Salyut beacons.*
20.008	*Widely used channel for both manned and unmanned missions*
29.330, 29.340, 29.402	*RS satellite downlink*
29.410, 29.460	
19.990, 19.995	*Tyuratam launch support frequencies*

Acknowledgments

I would like to thank Harley C. Gabrielson, K6DS for his assistance with this article.

Useful Sources

How to Tune the Secret Short Wave Spectrum, Harry Helms, Tab Books, *1981.*

Soviet Space Programs, 1971–75, Library of Congress, 1976.

ARE YOU MISSING OUT

. . . on the excitement and information in *Space Education*?

1983's first issue contains:

Visualising the future: how artists have paved the way in preparing Man for his next leap forward.

Orbit '81 Student Project: how some American school pupils are building their own Shuttle experiment.

National Air & Space Museum: The glory and the grandeur on show to visitors, from Lindbergh's *Spirit of St. Louis* to manned space capsules.

plus techtonics from orbit, helping the less developed countries, emblems of US manned missions, video teleconferencing by satellites, vehicles in fact and fiction, news, reviews, your letters . . . and much more.

You can still order your copy now;
1981 and 1982 issues £1.50 each (2 each year),
1983 issues £4.00.

FROM THE SECRETARY'S DESK

Modes of Address

One of the things I have always intended to do, but never done, was to keep a collection of letters using queer modes of address. The variation is almost unimaginable and quite beyond description. If we ignore those which come from an ignorant fellow who begins "Hallo Cock!" there are many which recognise my station and which are respectful, even fawning. Some lay it on just a bit too thickly, especially if followed with a way-out request of their own. For example, after the usual Blessings, one correspondent added:

"send me magazines of your beautiful and famous MOTION PICTURES. I should be grateful again if you could send me some of your TOYS. As you send it to me, God will bless you in all your works. I hope by the name of our Lord Jesus Christ that you will send me what I am asking you".

If we disregard those with ulterior motives and concentrate on the more servile we have "Distinguished Sir", "Esteemed Sir", "Reverend Sir", or courtesy titles such as Agent-General, Secretary-General and some so exalted that they cannot be published here. A few arrive as "Dear BIS" – the address thus being in the grand style. Others indicate Royalty, recognising my blue blood. One had no salutation at all. All it said was *"I'm sorry about the writing but I have no time to explain"*. He didn't sign it either.

More upsetting was a missive from Spain addressed "To the Workers Interplanetary". It was a promising start but interest vanished when it turned out to be holiday greetings from France, sent to the girl staff members only by Dennis the postman. There's no Christmas box for *him* this year, I can tell you.

A slightly different mode of address was used by another correspondent who sent everything to the Society c/o No. 10 Downing Street. Over 200 letters and postcards were involved. They didn't take long to read: they were all exactly the same.

That particular correspondent probably didn't expect a reply. Not so, another individual. Returning from a week's leave I found eight letters from the same person, written at the rate of one a day plus two on Sunday, the last complaining that no replies had been received to the other seven.

The content of some letters leaves much to be desired. One from Welsh TV recently ran: *"I should particularly like to know in what sort of activities you participate, whether you dress up or do anything that might be considered mildly eccentric."*

Truth to tell, I've always thought it was *they* who were odd.

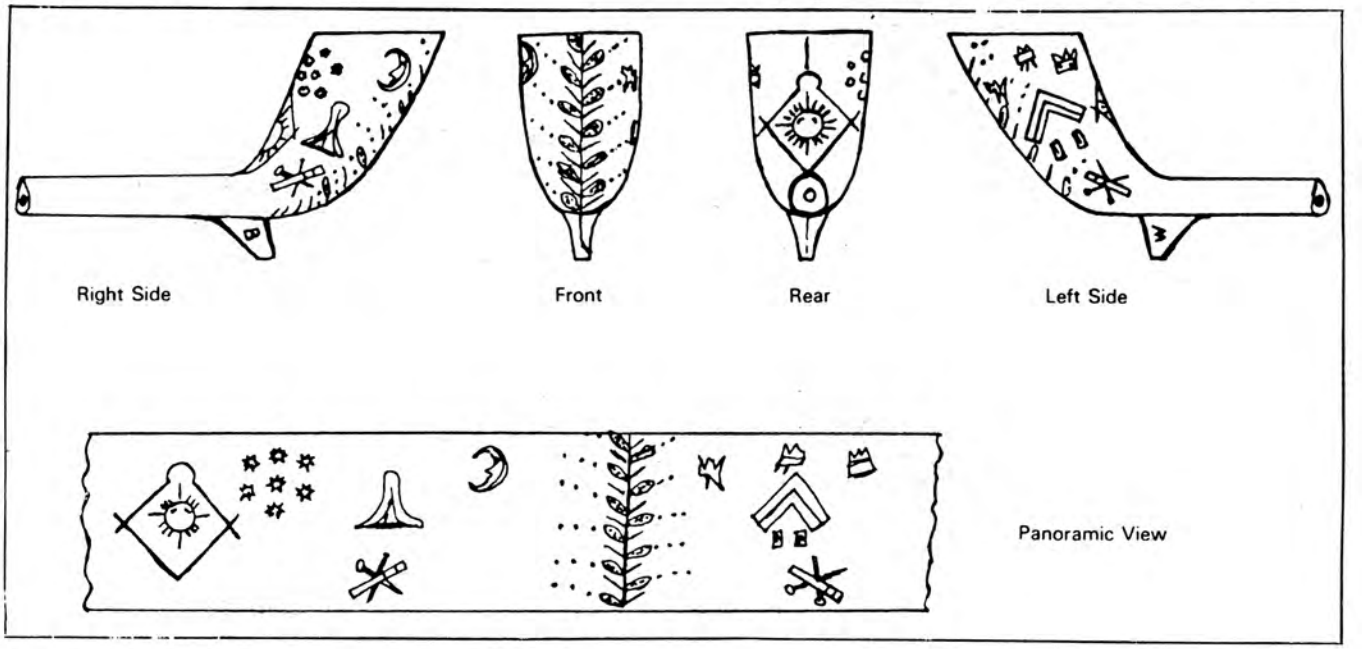
Astronomy in the Pipeline

The traditional English clay pipes are a marvellous expression of artistic feelings and impressions which have often reflected the signs of the times. Early pipes were small and plain (tobacco was *very* expensive) but gradually shapes and decorations were evolved which were not only beautiful but highly functional and easily held by a curled finger. As a result they are fascinating to collect.

Recently our President, Tony Lawton, acquired an old English clay pipe which has a variety of astronomical scenes around the bowl. The artist has shown his ideas of the Sun, the Moon, seven stars and certainly one but, possibly, two comets.

Around the left hand side of the bowl are the chevrons, crowns and tabs of a gunnery officer. To emphasise the artillery aspects, the lower section of both sides of the bowl is decorated with cannon barrels criss-crossed with ramrods and barrel sponges.

The Sun is shown as a radiant disk enclosed by a rectangle and topped by a "comet" which is most likely a pair of dividers or navigational compasses. The Moon is shown as "The Man in the Moon" while the seven stars are arranged in a regular hexagon with



The clay pipes as described in "Astronomy in the 'Pipeline", above.

Recent visitors to HQ will have noticed that the front step and both surrounds have been nicely tiled, giving it a very smart appearance and, incidentally, pretty-well disposing of the water penetration through seepage which had previously been a problem. The trouble is that the steps now look so smart that we are itching to re-do the whole of the front of the building again.

the seventh star at the centre, possibly an artistic rendering of the Seven Sisters or the Seven Stars in the sky from the English carol "Green grow the Rushes O!"

The "comet" appears to have a head and a classical "tail" so whether it commemorates an appearance of Halley's Comet I cannot really say, but if it does then it may have been the reappearance in 1835–6 for the pipe is typical of that period.

It is a fascinating object, but who was its original owner? Who conceived the design of the mould and where and when was it made. Can any reader help?

Where is Everything?

Members often express surprise that we lack particular items of equipment. The absence of display units is a good case in point. Not everyone appreciates that our subscription income is almost wholly absorbed by expenditure i.e. we return to members in magazines and services practically all we receive, with no fat surplus to spend on other things.

For all these other things we rely on gifts, donations, profits from saleable items and similar windfalls, but it is going to take a long time before we possess all the things members reasonably expect us to have!

One thing they won't fail to notice, however, is that the Conference Room has been carpeted at long last, an initial improvement to get it ready for our 50th Anniversary celebration dinners. We have also taken the opportunity to re-paint the door-frames and wainscotting so the overall appearance is much improved.

A sigh of relief is due on another account for the Conference Room had to be regularly polished. This marked easily and, after a while, produced white footprints which extended over most of the building. The trouble is that they were just oridinary footprints, replicas of the footprints of the first men on the Moon. We enjoyed seeing those stencilled on the pavements around Cape Canaveral during the Apollo flights and often thought how appropriate it would be to have one or two on our own account.

More progress, too, when we got rid of our old filing cabinets, with a sigh of relief. We got £10 for the lot, which shows how wornout they were.

How Did We Do It?

I am frequently asked how the Society possibly managed to acquire its new HQ building. Before it was cleared the site was a dreadful place and the conversion required was enormous. Most questioners, however, really want to know how we managed to *pay* for it, with admiration for the bravado shown in undertaking such a formidable task.

In all truth, the task at first seemed insuperable. The main aim was simply to buy the site and let the future decide how far we could progress from that point on. The first Appeal, therefore, was to raise money simply to secure the site, with some urgency as we were already under threat of ejection from our Bessborough Gardens address.

The small committee set up to try to organise things had little previous experience to guide it. One of the first drafts prepared was to try to notify members of our plight. It never appeared. It was in cartoon form intended to highlight the risk of ending up on the street. Fortunately, the Committee refused to sanction it on the grounds of melodrama.

With the building safely paid for, we are now giving attention to the ancillary equipment to go with it. There are so many things needing attention that we simply cannot buy from current income more than a small fraction of the things we need, let alone those which

We wouldn't mind this

But please NOT *THIS !!!*

a Society like ours *ought* to have, especially as we are trying to keep fees down to the lowest possible level at the same time.

This is why we need help from members. We already have an Appeal for the equipment needed to develop our range of publications and meetings but, besides these, there are many other items which, if we could secure them, would add to our prestige and stature.

The other day we received a brochure from a Planetarium, appealing to the public to contribute to *specific* items. This sounds a good idea for our own list includes many specific items, ranging in cost from £25 upwards.

It's not just equipment, but library books also, that we need. Nor is it essential to make a gift now. It can be later – perhaps even by Will if preferred.

Fore and Aft

Not all problems are capable of solution. One such occurred some years ago when I was required to pay a visit to the RAF College of Air Warfare in Lincolnshire to discuss space matters. Transport was provided from Northolt by a heavy, lumbering Transport Command aircraft.

All went well until I peered through the window as the aircraft rolled to a stop. Drawn up in the foreground was the station band, complete with bandmaster, a guard of honour and a group of high-ranking officers. A quick look round confirmed the fact that I was the only passenger so I could only deduce that someone had made an enormous mistake.

Crisis mounted upon crisis as I emerged to alight from the aircraft. Exit was by a long thin ladder, placed almost vertically. The problem to be resolved immediately was whether I should climb down backwards, gingerly clasping the sides and presenting the playing band, guard of honour, etc. with an imposing view of my backside or whether I should risk life and limb in attempting to descend, face-first and possibly come to an untidy end at the feet of the welcoming host.

Shakespeare knew of such things: there is a time for greatness he averred. Grey-faced I stiffly descended the ladder, face first. It took an eternity.

Once on the ground courage returned. I stepped forward and all was well. But to this day, I have never been sure of the correct way to emerge from that aircraft.

Keeping up our Magazine

Magazine production costs have been rising both here and in America but, in the UK, this has been particularly acute. At one time UK publications, particularly books, used to be considerably cheaper than their equivalents in America. The reverse is now the case though the introduction of new printing technology in the UK, if it can be achieved in spite of opposition, will help to alleviate the position. Meanwhile, the slowing-down of inflation has had many beneficial effects, not least in helping us to keep our UK subscription rates level and reduce dollar rates drastically.

Even though we lie at the low end of the subscription range, as far as UK rates are concerned, the Council is far from happy with the situation when comparing our rates in the world market.

If we are to hold our rates further, absorb inflationary increases (most of which come from the nationalised corporations) and improve our publications – all at the same time – we *have* to increase our income base. Part of this must stem from the introduction of new members, hence the Council's interest in securing help from every willing member in our drive to promote the Society, publicity-wise and in every other practicable way, to provide a rapid influx of new members to support our cause.

Comings and Goings

Eric Waine, who members will most recognise as the projectionist at Society meetings for some years past, has now joined the Society on a part-time basis, his predecessor, Alan Farmer, having departed to higher realms.

Another recent addition to our part-time team is Ray Sweetman, fresh and blooming with success after his "A" level work in Biology and about to follow a part-time course at Birkbeck College.

Lynda Lawford

Sue Mandry

A few words about the girls downstairs will not be amiss. Lynda Lawford joined us from Intasun, tour operators, where she worked for four years as a secretary. Her job brought her the "perks" of free flights, though not to such faraway places with strange-sounding names as we feature in the pages of *Spaceflight*.

Sue Mandry was an Administration Assistant for the Hotel Catering and Institutional Management Association so she was already familiar with some of the problems of running an organisation such as ours.

WILL YOU BE AT SPACE '84?

The resounding success of Space '82 – with its host of space experts and personalities presenting overviews of the space scene – has paved the way for its successor: Space '84.

Once again we will assemble a unique collection of contributors intimately involved in astronautics. Our theme will take us deep into the Cosmos and into the future.

The preliminary programme includes the following main sessions:

New Frontiers	Space Workshop
Foothold in Space	Discovering the Universe
The Future of Mankind	Ways and Means

This range of exciting topics will make it an event not to be missed. Attendance will be limited to a total of 400 members and guests, to retain that familiar, friendly atmosphere that everyone enjoyed so much at Space '82. Registration forms will be sent out towards the end of the year. Apply to the Executive Secretary, 27/29 South Lambeth Road, London, SW8 1SZ, England.

MILESTONES

September 1983

7 NASA award the $2000 million, two year contract for processing Space Shuttles for launch to the team headed by Lockheed. At present, the Rockwell team handles the vehicle.

8 The Satcom IIR commercial communications satellite is launched by Delta from Florida. It is due to arrive at its 72°W geostationery orbit position on the 19th to begin its 10 years of operations.

12 It is reported that the privately-owned W. German OTRAG company is planning its first orbital launch by 1985–6. It is presently launching sounding rockets from Kiruna in Sweden as a prelude to combining the units into an orbital launcher.

16 Shuttle Orbiter *Columbia's* payload bay doors are closed over the Spacelab modules in preparation for the STS–9 mission. Mating with the External Tank and boosters is due to begin on the 23rd.

17 The UK Home Secretary announces that two further TV satellite channels to be run by the IBA (the commercial TV governing body) will be added to the two awarded to the BBC. The new channels could begin in 1988, following those of the BBC in late 1986.

19 India's Insat 1B communications satellite, released during the STS–8 mission, continues its test period following successful deployment of a stuck solar array. Controllers turned the satellite to heat the array with sunlight.

24 The scheduled launch date (as of the 17th) for the seventh Ariane flight. A delay from the 15th was caused by checks on the Intelsat V satellite payload.

26 STS–7 astronauts Dr. Sally Ride (Mission Specialist) and Frederick Mauck (pilot) mark their visit to the UK with a press conference at the US Embassy.

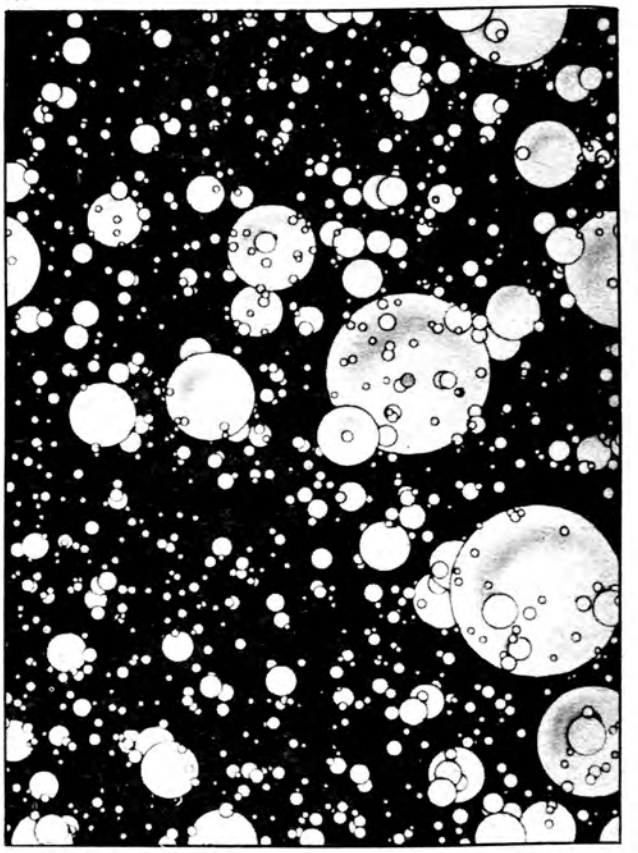
"ASTRONAUTICS HISTORY" JBIS

The December 1983 issue of the Journal is devoted to Astronautics History, edited by Mitchell Sharpe. The history of lifting reentry vehicles leading to the development of the Space Shuttle is extensively covered in "The Path to the Space Shuttle" by Richard Hallion; Frederick Ordway and Frank Winter contribute "Pioneering Commercial Rocketry in the USA: Reaction Motors Inc, 1941–1958"; and a piece of British rocket history is described by John Becklake *et al* in "The Science Museum's Cunningham Lifesaving Rocket".

Individual copies of *JBIS* are available from The British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ at £2 ($4) each.

DO YOU KNOW?

This month's picture puzzle is actually an artist's concept of something yet to be photographed directly, although it has been probed by radio waves. What is it?



Answer: it is a 10 m cube of Saturn's A-ring, populated by bodies ranging from the size of marbles (2 cm) to beach balls (70 cm). The concept is based on measurements obtained as Voyager 1 flew behind the rings in November 1980.

DO YOU REMEMBER?

25 Years Ago. . .
13 December 1958. Gordo, a squirrel monkey, is launched inside a Jupiter missile nosecone to provide biomedical data for the manned Mercury programme.

20 Years Ago. . .
13 December 1963. NASA saves $90 M by cancelling five Ranger flights (Nos. 10–14).

15 Years Ago . . .
13 December 1968. Lunar Module 5 passes its final test before transfer to the Cape. LM-5 is better remembered as Apollo 11's *Eagle*.

10 Years Ago . . .
3 December 1973. Pioneer 10, launched in March 1972, passes within 130,000 km of the cloud tops of Jupiter, returning the first close-up pictures.

5 Years Ago . . .
4 December 1978. Pioneer Venus 1 enters orbit around Venus to begin its studies of our sister planet.

D. J. SHAYLER

SATELLITE DIGEST – 168

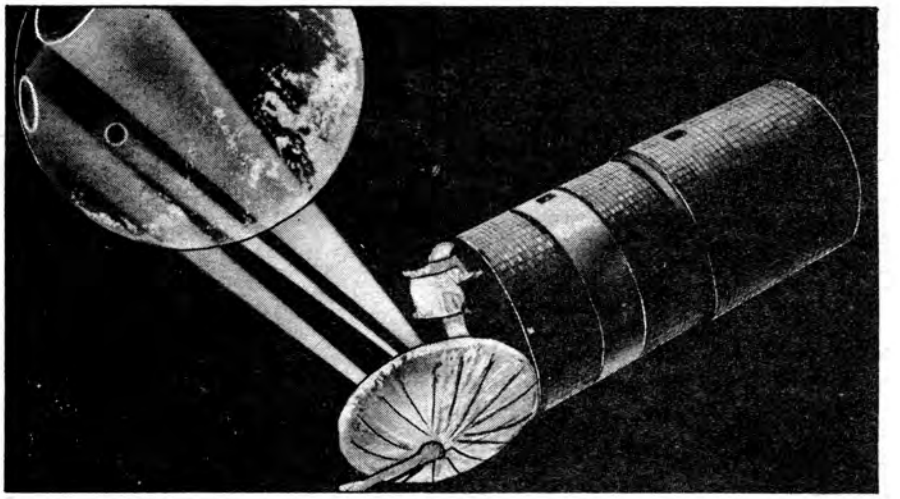
Robert D. Christy
Continued from the November issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

OSCAR 10 1983-58B, 14129

Launched: 1159, 16 Jun 1983 from Kourou by Ariane (L-6).
Spacecraft data: Three pointed star shape, 1.26 m span, 0.43 m high. Mass 130 kg (90 kg after manoeuvres).
Mission: Third generation, German-built Oscar satellite providing amateur radio communications. Its main purposes are to serve as an educational aid, to provide communications over large areas using relatively inexpensive equipment, technological studies, assessing the effectiveness of the orbit for communications,and to demonstrate the practicability of using a microprocessor for managing and monitoring the satellite's operation.
Orbit: Initially 197 X 35421 km, 624.33 min, 8.6 deg; later to be manoeuvred by onboard propulsion to 1500 x 35800 km, 660 min, 55 deg.



The Hughes HS-376 type commercial communications satellite was used in three of the launches in this month's "Satellite Digest": Telesat 7, Palapa 3 and Galaxy 1 (over page).

STS 7 1983-59A, 14132

Launched: 1133*, 18 Jun 1983 from the Kennedy Space Center.
Spacecraft data: Delta winged spacecraft, 37m long, 24m across, mass around 69 tonnes.
Mission: Second flight of Shuttle Orbiter *Challenger* with crew of Crippen, Hauck, Fabian, Ride and Thagard. Mission events include launching two satellites, Palapa 3 and Telesat 7, and testing of the remote manipulator arm using the SPAS-01 pallet. *Challenger* landed at Edwards Air Force Base on 24 Jun 1983 instead of at the Kennedy Space Center as originally planned, due to adverse weather conditions.
Orbit: 295 X 320 km, 90·52 mins, 28·46 deg.

TELESAT 7 1983-59B, 14133

Launched: 2101*, 18 Jun 1983 from the payload bay of *Challenger*.
Spacecraft data: 2·16m diameter cylinder, initially 2·82m long but extending to 6·7m when solar array fully deployed. Mass 1238 kg including 578 kg of manoeuvring and attitude control fuel. It is spin stabilised and is based on the standard Hughes HS-376 vehicle.
Mission: Canadian communications satellite providing telephone and television channels.
Orbit: Initially as *Challenger* but injected into a geostationary transfer orbit by a payload assist module at 2146, 18 Jun 1983. Later manoeuvred to, and stabilised, in geosynchronous orbit.

PALAPA 3 1983-59E, 14136

Launched: 1336, 19 Jun 1983 from the payload bay of *Challenger*.
Spacecraft data: As Telesat 7 except masses are 1200 kg and 550 kg respectively.
Mission: Part of an Indonesian synchronous communications satellite system.
Orbit: Initially as *Challenger* but injected into geostationary transfer orbit by a payload assist module for later manoeuvres and stabilisation in geosynchronous orbit.

SPAS-01 1983-59F, 14142

Launched: Initially at 0805*, 22 Jun 1983 from the remote manipulator arm of *Challenger*.
Spacecraft data: Based on Spacelab pallet, mass around 1500 kg.
Mission: Carried science and technology payload and was used to test satellite release and retrieval using the Shuttle's manipulator arm. Initial capture was made immediately after release but the pallet was released and retrieved four times in all over a ten hour period and separated from the Orbiter by up to 300m.
Orbit: as *Challenger*.

OPS 0721 (Big Bird) 1983-60A, 14137

Launched: 1840, 20 Jun 1983 from Vandenberg AFB by Titan 3D.
Spacecraft data: Cylinder approx 15m long and 3m diameter, mass around 13,000 kg.
Mission: Military photo-reconnaissance satellite with film return capsules.
Orbit: 157 X 230 km, 88·40 min, 96·45 deg, manoeuvrable.

Sub-satellite 1983-60C, 14139

Launched: 1840, 20 Jun 1983 from Vandenberg AFB, pick-a-back with OPS 0721.
Mission: Military, probably electronic reconnaissance.
Orbit: 1290 X 1290 km, 111·41 min, 96·67 deg.

COSMOS 1470 1983-61A, 14147

Launched: 0000, 23 Jun 1983 from Plesetsk by F vehicle.
Mission: Probably electronic reconnaissance.
Spacecraft data: Not available.
Orbit: 635 X 670 km, 97·80 min, 82·52 deg.

SOYUZ T-9 1983-62A, 14152

Launched: 0912*, 27 Jun 1983 from Tyuratam by A-2.
Spacecraft data: Near spherical orbital compartment, conical re-entry module and cylindrical instrument unit with solar panels. Length approx 7·5m, max diameter 2·2m and mass around 7,000 kg.
Mission: Carried crew of Vladimir Lyakhov and Alexander Alexandrov to the Salyut 7/Cosmos 1443 complex. Soyuz T-9 docked with the rear unit of Salyut 7 at 1046, 28 Jun 1983. The crew unloaded cargo carried by Cosmos 1443, which undocked at 1440, 14 Aug 1983 and returned a capsule to Earth with about 500 kg of cargo from the station. At 1425, 16 Aug 1982, Soyuz T-9 undocked from Salyut with the crew aboard, Salyut was rotated through 180 degrees to allow the Soyuz T to re-dock with the forward port and release the aft unit for occupation by Progress 17.
Orbit: Initially 190 X 222 km, 88·56 min, 51·61 deg then manoeuvred to dock with Salyut in an orbit of 325 X 337 km, 91·08 min, 51·61 deg.

HILAT 1983-63A, 14154

Launched: 1530, 27 Jun 1983 from Vandenberg AFB by Scout.
Spacecraft data: Based on the Transit navigation satellite, an octagonal cylinder about 1m long and 0·5m diameter. The mass is 113 kg.
Mission: Ionospheric research at high latitudes from the US Air Force.
Orbit: 770 X 838 km, 101·02 min, 82·03 min.

COSMOS 1471 1983-64A, 14156

Launched: 1510, 28 Jun 1983 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with a spherical re-entry module, instrument unit and a supplement payload at the forward end. Length about 6m, diameter (max) 2·4m and mass about 6,000 kg.
Mission: Military photo-reconnaissance, recovered or re-entered after 30 days.
Orbit: 185 X 344 km, 89·79 min, 67·15 deg, manoeuvrable.

GALAXY 1 1983-65A, 14156

Launched: 2308, 28 Jun 1983 from Eastern Space and Missile Center by Delta 3920 plus payload assist module.
Spacecraft data: Similar to Telesat 7 with masses of 1,218 kg and 698 kg respectively.
Mission: Commercial satellite offering 12 communications channels available for sale or lease. The satellite was built and launched by different divisions of the Hughes organisation.
Orbit: Geosynchronous about 134 deg west longitude.

GORIZONT 7 1983-66A, 14160

Launched: 0000, 1 Jul 1983 from Tyuratam by D-1-E + apogee motor.
Spacecraft data: Cylinder with pair of solar panels and an aerial array at one end. Length 5m, diameter 2m and mass in geosynchronous orbit 200 kg approx.
Mission: To provide telephone, telegraph and television relay links through the "Moscow" system both within and outside the Soviet Union.
Orbit: Initially a low, parking orbit at 51·5 deg inclination, then transferred to a geosynchronous one.

PROGNOZ 9 1983-67A, 14163

Launched: 1217*, 1 Jul 1983 from Tyuratam by A-2-e.
Spacecraft data: Cylinder approx 2m long and 2m diameter, carrying four solar panels. Mass is around 1,000 kg.
Mission: Ionospheric and magnetospheric studies, and specific research into residual radio emissions from the "big bang", using scientific apparatus provided by Czechoslovakia and France as well as the USSR.
Orbit: 380 X 720,000 km, 38,448 min, 65·5 deg.

COSMOS 1472 1983-68A, 14169

Launched: 0800, 5 Jul 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1471.
Mission: Photo-reconnaissance, recovered after 14 days. All or part of the payload was an Earth resources package.
Orbit: 338 X 362 km, 91·56 min, 82·35 deg after manoeuvres.

COSMOS 1473-1480 1983-69A-H, 14171-14178

Launched: 0030, 6 Jul 1983 from Plesetsk by C-1.
Spacecraft data: Probably spheroidal in shape, around 1m long and 0·8m diameter, mass around 40 kg each.
Mission: Eight satellite launch to provide tactical communications between troops or units in the field.
Orbit: 1,397 X 1,465 km, 114·46 min, 74·03 deg (lowest) and 1,464 X1,522 km, 115·84 min, 74·03 deg (highest).

COSMOS 1481 1983-70A, 14182

Launched: 1930, 8 Jul 1983 from Plesetsk by A-2-e.
Spacecraft data: Possibly a cylindrical body surmounted by a conical motor section, and carrying a "windmill" of six solar panels. Mass around 2,000 kg.
Mission: Part of the Soviet Union's missile early warning system.
Orbit: Initially 643 X 39,200 km, 707·39 min, 62·93 deg, later manoeuvred to 718 min period by raising apogee in order to ensure daily ground track repeats.

COSMOS 1482 1983-71A, 14185

Launched: 0940, 13 Jul 1983 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1471.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 352 X 413 km, 92·21 min, 69·98 deg.

SPECIAL ISSUES OF JBIS

The *Journal of the British Interplanetary Society* has appeared since 1934. Many of today's developments first saw light in its pages. Nowadays it is a 48pp monthly with a worldwide reputation, with each issue devoted to some special aspect of space studies. The annual subscription is £20 ($34). Individual copies cost £2 ($4) each post free. Some recent special issues are described below.

Interstellar Studies
"Red Cover" issues of *JBIS* are published quarterly. These are unique, covering all aspects of interstellar travel, communications and extraterrestrial life. Over 40 separate issues have appeared to date, thus making it the most comprehensive source of reference to star travel now available.

Space Chronicle
Up to four issues appear each year. Papers review past and present space projects at a similar level to but at greater length and in more technical detail than in *Spaceflight*.

Astronautics History
US space historian Mitchell R. Sharpe edits these special annual issues, concentrating on reviews of space history.

Soviet Astronautics
This is another special once-a-year issue, this time on Soviet space activities. The October 1983 edition includes papers on the Soyuz manned spacecraft, nuclear-powered satellites and cosmonaut histories.

Space Technology
These issues feature technical papers on important astronautical topics. Some examples from papers in the September 1983 issue are: "Space Station Technology", "Nuclear Waste Disposal in Space" and "Aerocapture and Aero-assisted Orbit Transfer".

Other Special Issues
Many other special issues are published as occasion demands, e.g. on Space Communications, Halley's Comet, Orbital Dynamics, Infra-Red Astronomical Satellite, Image Processing, etc.

Back Issues
A list of back volumes, bound and unbound, is available. Single issues are also available. Please specify your requirements, with s.a.e. Reprinted volumes are available from: Kraus Reprint Corp., 16 East 46th St., New York, N.Y. 10071, U.S.A. Microfilm copies can be obtained from: Swets & Zeitlinger, Keizergracht 487, Amsterdam-C, Holland.

Science Fiction Artists

Sir, The article "The 1950's – A Pivotal Decade", in the July/August issue, does an excellent job of covering the events and influences of that period. However, we should mention one artist who without any doubt had a definite influence on three of the comic serials mentioned.

This artist is none other than Ralph A. Smith. His influence can be seen in Dan Dare, created and illustrated by Frank Hampson; the "Journey into Space" "Planet of Fear" story appearing in *Express Weekly*, created by Charles Chilton and drawn by Tacconi; and " 'Space' Kingley", drawn by Rob Jobson.

Take, for instance, the second panel of Jet Morgan (*Express Weekly*, No. 85, May 5, 1956) showing the second stage firing of Morgan's rocket. It appears to be the same as R. A. Smith's illustration on p.25 of "Exploration of the Moon", published in 1954. In the previous issue the lunar launch pad in Jet Morgan also bears a similarity to launch pads on Earth and the Moon in the above mentioned book and on p.29 of *High Road to the Moon*.

The same launch pad shows up in the Dan Dare story "Operation Saturn" in the last two frames of p.2 *Eagle* Vol. 3 No. 51, 27 March 1953. The same pad also appears in the first two 'Space' Kingley annuals, the first of which came out in November 1952, predating both the *Eagle* and *Express Weekly* examples.

I am sure that a further study of the three above mentioned illustrated works would bring to light more of R. A. Smith's influence and, ultimately, the research of the BIS. In a 'phone conversation with the artist of "Space" Kingley, Rob Jobson, he told me that his inspiration came from the film "Shape of Things to Come", the paintings of Chesley Bonestell, the Dan Dare series in *Eagle*, recent American research and last, but not least, the work of the BIS. Whether this is true of the other above mentioned serials I am not sure.

CHARLES W. EVANS-GUNTHER
Clwyd, N. Wales

Society Publicity

Sir, I can add a further note to the Executive Secretary's remarks in the November issue on giving lectures to other audiences. Sometimes, the organisers are embarrassed if the number in the audience is below expectations. For this reason, early on, I demanded an audience of three as my basic minimum. This may seem small but it comes from a story I once heard about an international meeting held in a major American town. The speaker, on reaching the rostrum, was incredulous to discover that he had an audience of just one person. Putting the best possible face on it, he started by saying how much time had gone into preparing his paper, the cost of the research and the experiments, the printing and the numerous illustrations, besides all his travel and hotel expenses – and many other things besides. Because of all this he was still going to give his paper.

At that point he was interrupted. His one-man audience shouted out, "For goodness sake get on with it. I'm the next Speaker!"

So I've always thought my 50 per cent increase perfectly satisfactory.

A. NON

SNIPPETS

The UK in Orbit

Sir, Your mention of the fact that astronaut Tony England will be a member of the STS-24 mission suggests to me that the UK will be vicariously represented in space. Had astronaut John Bull not been physically disqualified several years back, *John Bull* might have accompanied *England* into orbit.

MITCHELL R. SHARPE
Huntsville, Alabama, USA

Way of the World

Sir, It's a pity that the media coverage of the seventh Shuttle mission couldn't have concentrated more on the work astronaut Sally Ride did in space, rather than waste time with silly comments on make-up and hairstyles!

J. S. Multon
Devon

Not a Planet

Sir, The comment on the "discovery of a planet circling T Tauri", in "Milestones" of *Spaceflight* for Sept/Oct 1983, p.346 requires amending. An infrared-emitting "star" in the double star system T Tauri was *hypothetically* proposed as a "planet", but this has, so far, not been confirmed by (other) astronomical observations.

G. v.d. HAAR
Ministry of Education and Science,
Space Policy Department, The Hague

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

AN INVITATION TO OVERSEAS MEMBERS TO ADDRESS THE SOCIETY

The Programme Committee is interested in reaching overseas members engaged in astronautics who would be willing to address meetings at HQ on some interesting aspect of their work. They extend a cordial invitation to any of our members planning to visit the UK or, indeed, their colleagues, who would like to participate in an evening lecture, symposium, or discussion in this way.

Members interested should contact the Executive Secretary at HQ, 27/29 South Lambeth Road, London, SW8 1SZ, England as soon as their plans are known.

The Exploration of Outer Space with Cameras
M. M. Mirabito, McFarland (UK: Bailey Bros. and Swinfen), 170pp, 1983, £17.95.

This book chronicles the use of TV cameras and other visual imaging systems used in NASA unmanned space probes to the Moon and planets. It details not only the devices themselves but also the development of the image processing and enhancement techniques for converting a spacecraft's transmissions into pictures.

The volume is divided, essentially, into three main sections. The first summarizes all the individual NASA space probe flights from Ranger to Voyager. The second analyses a selection of photographs of other worlds transmitted *via* such craft, while the third mops up various matters such as camera calibration, applications, etc.

This is not a technical volume on photography requiring specialised knowledge but more a non-technical historical summary.

Low Light Level Detectors in Astronomy
M. J. Eccles *et al*, Cambridge University Press, 1983, 187pp, £20.

By the very nature of their work, optical astronomers have to do the best they can with the extremely faint light from stars and other celestial objects. Considerable advances in detector technology have not only enabled them to extend their knowledge by observing fainter and fainter objects, but have also enabled telescopes of only modest sizes to be used in projects which formerly would have required the largest instruments available.

This volume is concerned with various devices used to detect the light coming in from such objects e.g. photographic, TV and electronic detectors. The aim is to compare the various types of detector available and explain why one might be better than another in any particular situation. There is no such thing as an ideal detector, though it is possible to draw up a list of the desirable properties that an ideal device should possess. Those that astronomers actually have at their disposal always fall short of this ideal in one respect or another, so an appreciation of strengths and weaknesses is needed to ensure efficient operation.

The range of detectors available is covered very fully. Much space devoted to modern electronic detectors, such as the charge coupled device or CCD.

The Very Early Universe
Ed. S. W. Gibbons *et al.*, Cambridge University Press, 1983, 480pp, £25.00.

At the beginning of this century it was accepted, unquestionably, that our Universe was essentially uniform and static, apart from the local motions of stars and planets. Most people preferred to believe that it had existed forever, because this avoided all questions about the actual beginning. This was the picture until Einstein formulated his general theory of relativity in 1915. This led to the abandonment of the static picture of the Universe in the 1920's when observations of nearby galaxies showed that they were receding from us at a rate proportional to their distance.

The hot big bang theory postulates that the Universe expanded in a homogeneous and isotropic manner from an initial event ten to 20 thousand million years ago. All observations made in recent years agree with this theory but do not explain other features of the present Universe e.g. the fact that large scale homogeneity and isotropy exist. It merely assumes that these were initial conditions at the beginning.

Even at the present day, many problems still remain e.g. why was the Universe spatially uniform and isotropic in the first place; why, despite the above uniformity, were there small irregularities which later became stars and galaxies? Did it contain significant numbers of exotic objects e.g. small black holes? These properties of the Universe can be accounted for, if at all, only in terms of processes which took place in the very early stages.

The volume presents a co-ordinated account of recent advanced in our understanding of the origins of the Universe. Relevant ideas from particle physics and cosmology are introduced in wide-ranging review articles, supplemented by a number of research papers describing many of the latest developments. For example, it is suggested that the Universe may have undergone a period of exponential expansion as a consequence of being trapped in a metastable state of a phase transition. This might account for most of the otherwise unexplained features of the hot big bang model and is particularly interesting because it makes definite predictions which might be tested observationally over the next few years.

Space Processing, Products and Profits 1983–1990
Ed. D. Gump, Pasha Publications, 278pp, 1983, $97.

The US spent $25,000 million to get to the Moon and over $10,000 million developing the Space Shuttle,hence the usual initial reaction that space industrialization will be very expensive.

The fact is that much of this expenditure went to pay for a huge army of consultants, coordinators and others, many of whom would be dispensed with if lower-cost alternatives were pursued. For example, an industry-designed Shuttle would probably not attempt to accommodate all possible users but would operate with a limited ground crew and with major components bought "off the shelf" in the competitive market place. Thus, so it is argued, the cost of getting into space will accordingly plummet.

This special report provides business information on current and developing space applications, the present users and how space developments apply to specific industries. There is even a special section on the free flights on the Shuttle offered by NASA to companies which pioneer development of space-based Manufacturing processes. Only the first company to provide such experimentation will get the free flights – its competitors will not, hence a real application of the maxim "he who hesitates is lost".

The volume includes a complete copy of a special NASA report on "Commercial Opportunities in Space" prepared by McDonnell Douglas and Booz-Allen & Hamilton.

Astrophotography
B. Gordon, Pub. by the author, 128pp 1983, $12.50.

This book stemmed from a course offered at the Hayden Planetarium in the USA. Astrophotography is, basically, the knowledge and skill used to capture on film some of the spectacular beauty of the Heavens.

After a short introduction the book considers the main problems of exposure, image size and similar data, and then reverts to basic equipment. This is followed by examples of some easy subjects though the short description on photographing comets includes the prosaic comment "expose film as though it were going out of style, trying every focal length and exposure duration that you think might possible record anything".

The book then reverts to technical matters once more e.g. subjects for a driven camera, optical systems, subjects for long lenses, etc., ending with a number of suggestions for advanced techniques.

This is very much a book for the amateur astronomer planning to take up stellar photography seriously and needing a good practical down-to-Earth guide.

The British Interplanetary Society

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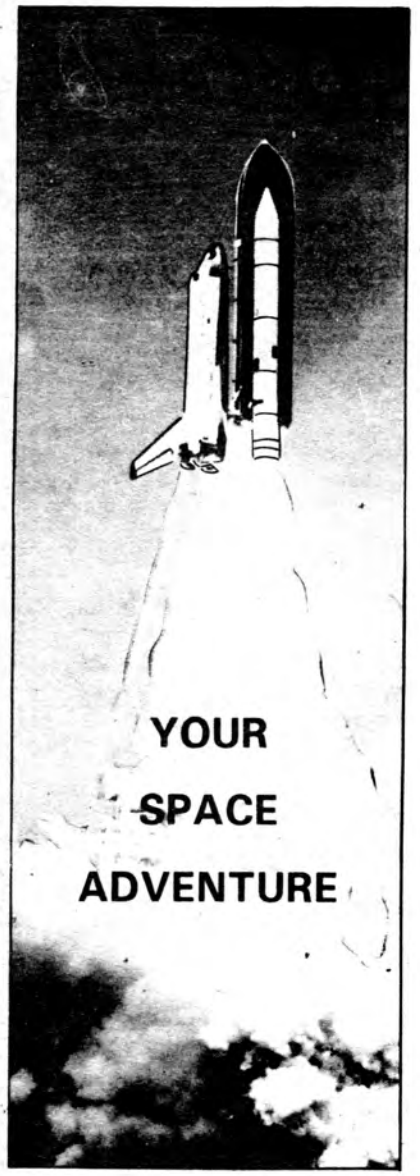
50th ANNIVERSARY 1933-1983



spaceflight
JBIS Space Education

If you want the full story of Man's journeys into the cosmos then look no further! The British Interplanetary Society publishes three excellent magazines, with something to suit all tastes.

The profusely-illustrated *Spaceflight* carries wide-ranging news and views on what is going on today in the space-world—it is vital reading for everyone interested in space travel. It deals with current events and future plans in news items and major articles, many of them written by leading space experts. Personal accounts give an "I-was-there" feeling to it all. And a lively correspondence section gives everyone a chance to air their views.

Spaceflight is not just a magazine; it is part of a network bringing together everyone interested in space.

JBIS holds an exceptional place in the history of space exploration. First appearing in 1934, when interest in such matters was regarded almost as a heresy, it has since become a leading international publication, greatly respected for its emphasis on key topics. Many of today's developments were originated in its pages.

JBIS devotes issues to specific topics, such as Interstellar Studies, Space Technology, Space Communications and Astronautics History. Its Space Chronicle issues include general articles of a review nature.

Over 40 "Interstellar Studies" issues of JBIS *have been published, making it the most comprehensive work on the subject*

Space Education is our latest venture. It's a twice-yearly magazine, established in 1981, devoted to the role of education in space exploration. It is a medium for the dissemination of information and the exchange of ideas on the teaching of space-related subjects and on their relation to the world of employment and industrial activities.

Membership of the Society entitles each member to receive either *Spaceflight* or *JBIS* free, with the other available at an extra cost of £20 ($34).

Remember! If you are under 18 then Society membership costs just £16 ($26)

Membership fees for 1984 are as follows:

	Sterling	US Dollars
Member (under 18)	£16	$26
Member (18–20)	£18	$30
Member (21+)	£21	$36
Fellow	£23	$40

SPACE SOUVENIRS

The Society produces a wide and varied range of items for sale, all of high quality. Why not buy a T-shirt or badge for yourself, or treat a friend? Remember, you'll not only support our work but also provide valuable advertising for the Society.

Binders

The ideal way of keeping your magazines in perfect condition. *Spaceflight* binders carry *BLUE* covers, those for *JBIS* are *GREEN*. Gold lettering on the spine identifies the magazine, volume number and year. Cost: £5 ($10 abroad) each. Note: *JBIS* binders fit post-1976 volumes.

T-SHIRTS

Our Society T-shirt has always been a popular item. Two styles are available: white with a large navy blue BIS logo on the chest, or navy blue with a pale blue logo.

The blue T-shirt in chest sizes 32-34, 34–36, 38–40 & 42–44 inches. The white T-shirt is available in the two smaller sizes only. Cost is £3.50 in the UK or £4 ($8) abroad. Please be sure to specify the style, colour and size when ordering.

SPACE TANKARDS

In response to many demands, glass tankards of the type presented to the Speakers at the Society's Space '82 conference are being produced to mark **Space '84,** to be held in Brighton, 16–18 November 1984. Orders (UK only – sorry but we can't run the risk of damage in sending abroad) should be *sent direct* (not to the Society) to:

Western Glass International, Western Glass Works Ltd., Armstrong Rd., Daneshill East, Basingstoke, Hants RG24 0QE.

The cost is £10 (postage & packaging free). All profits will be donated to the Society so this is your chance to obtain a unique souvenir and to benefit the Society at the same time.

50th ANNIVERSARY TIES

We have always produced a high-quality navy blue tie that will grace any space buff's apparel. Now, to mark our 50th year, we are re-introducing the former blue tie showing a rocket against a star background.

For our 50th Anniversary year, the rockets will appear in GOLD to show, unmistakeably, that we have every reason to be proud of our achievements.

As these ties will be unique souvenirs only a limited number will be produced, so please place your order now to avoid disappointment. Next year, the ties will revert to the silver once more. The cost is £6 UK or £6.50 ($13) abroad per tie.

BADGES

A range of badges with the Society's motif is available.

Enamel lapel badges (1 in. diameter) and cloth blazer badges (3 in. diameter) cost just £1 ($2) each.

A special metal car badge adds that distinguished look to any vehicle for only £3 (£3.50 or $7 abroad).

A selection of a dozen space photographs are available for only £1 ($2), post free. Please mark the order form "Photographs".

Please note:

When ordering please specify colour, size, quantity, etc. as appropriate. Please use the order form on the back.

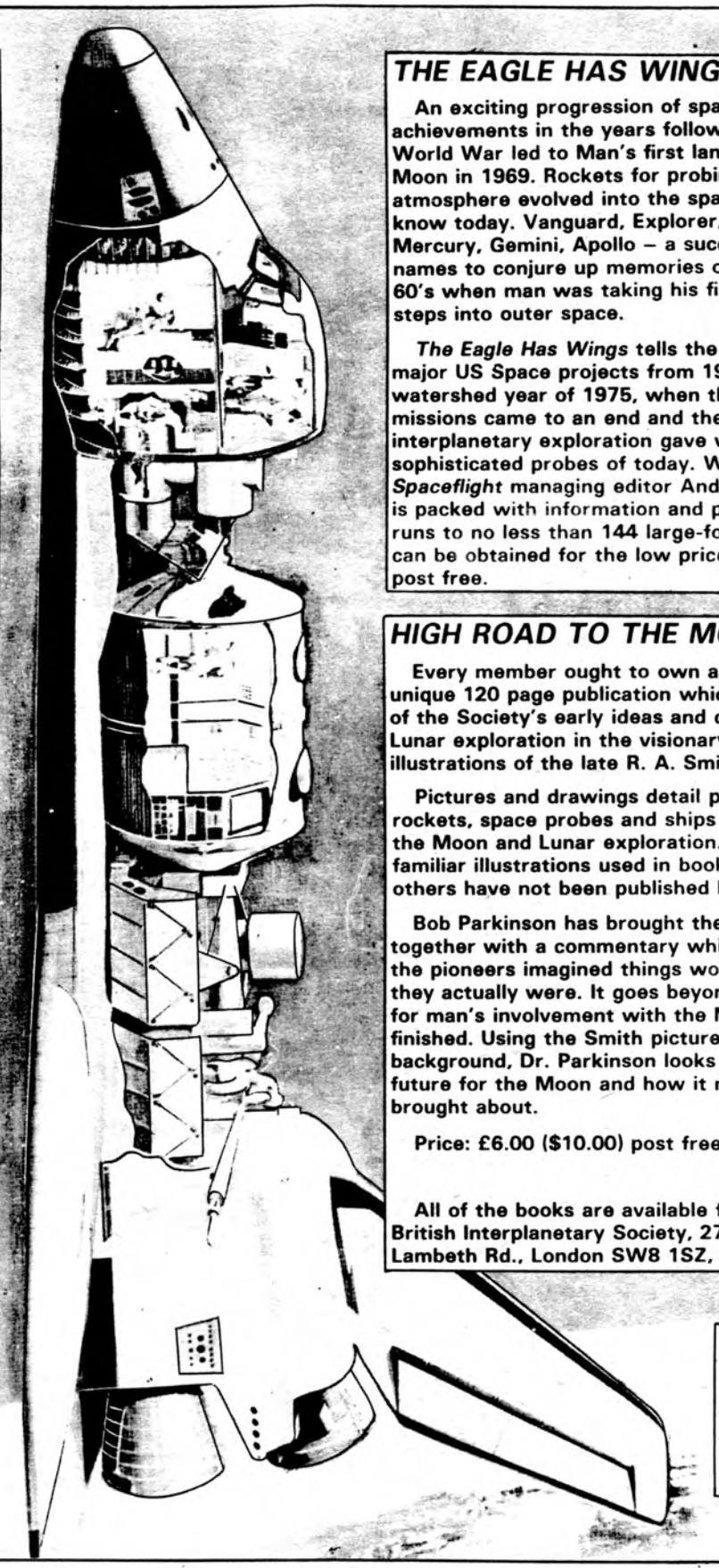
SOCIETY BOOKS

PROJECT DAEDALUS

The publication of the Project Daedalus Final Report marked the end of years of painstaking work by a group of BIS pioneers. The BIS received congratulations from around the world for its far-sighted project: designing a probe for man's first crossing of interstellar space.

The Final Report Report contains 24 papers spread over 192 large-format (A4) pages, summarising the four year study. The papers cover the overall spacecraft design, mission profile, computer systems, navigation, experiments and our knowledge of nearby stellar systems, some of them possibly with planets.

"Daedalus" is acknowledged as a milestone in the the development of advanced astronautics. Copies of the Report cost just £7.00 ($12.00) post free.



THE EAGLE HAS WINGS

An exciting progression of space achievements in the years following the Second World War led to Man's first landing on the Moon in 1969. Rockets for probing the upper atmosphere evolved into the space launchers we know today. Vanguard, Explorer, Atlas, Titan, Mercury, Gemini, Apollo – a succession of names to conjure up memories of the 50's and 60's when man was taking his first tentative steps into outer space.

The Eagle Has Wings tells the story of the major US Space projects from 1945 to the watershed year of 1975, when the Apollo missions came to an end and the first wave of interplanetary exploration gave way to the more sophisticated probes of today. Written by *Spaceflight* managing editor Andrew Wilson, it is packed with information and photographs. It runs to no less than 144 large-format pages and can be obtained for the low price of £7 ($12.00) post free.

HIGH ROAD TO THE MOON

Every member ought to own a copy of this unique 120 page publication which records many of the Society's early ideas and discussions on Lunar exploration in the visionary drawings and illustrations of the late R. A. Smith.

Pictures and drawings detail plans for orbital rockets, space probes and ships to take men to the Moon and Lunar exploration. Some are familiar illustrations used in books of the time: others have not been published before.

Bob Parkinson has brought these pictures together with a commentary which tells how the pioneers imagined things would be and how they actually were. It goes beyond the present, for man's involvement with the Moon is not yet finished. Using the Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.

Price: £6.00 ($10.00) post free.

All of the books are available from: The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ, England

spaceflight

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

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NOTICES OF MEETINGS

Film Show

Theme: **THE DEPTHS OF SPACE — II**

The second part of this film show will be screened in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **30 November 1983,** 7.00-8.30 p.m.

The programme will include the following:

(a) The Planet Mars

(b) Exploration of the Planets

(c) Jupiter Odyssey

(d) Rotation of Jupiter

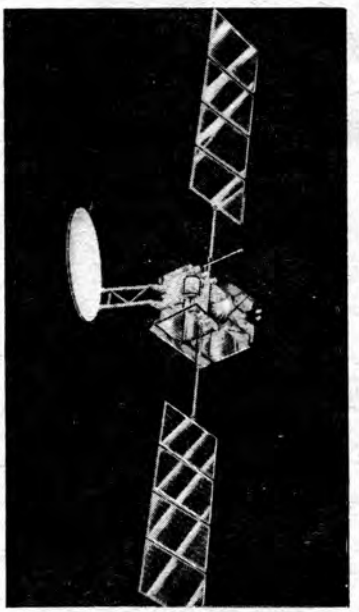
(e) Universe

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Film Show

SPACE BENEFITS

The use of space technology has brought countless benefits to Mankind. A few examples will be examined in a two-part film programme.



Part 1, on **11 January 1984**, 7.00–8.30 p.m. includes:

(a) Challenge and Promise
(b) Live *via* Early Bird
(c) Moonflight and Medicine
(d) The House that NASA Built
(e) Growing Concerns

Part 2, on **1 February 1984** 7.00–8.30 p.m., includes:

(a) Anatomy of Success
(b) Landsat: Satellite For All Seasons
(c) Hurricane Below
(d) David's World
(e) Space Navigation

Both parts will be screened in the Society's conference room, 27/29 South Lambeth Rd., London, SW8 1SZ. Members should apply in good time, enclosing a stamped addressed envelope.

Lecture

Title: **EXPLODING STARS**
by A. T. Lawton
President of the Society

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **4 April 1984,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

One-day Symposium

Theme: **SPACE TRANSPORTATION SYSTEMS**

A one-day symposium on the above theme will be held in the Society's Conference Room on **11 April 1984**, 9.30–5.30 p.m.

Offers of papers are invited. Potential authors are requested to contact the Executive Secretary at 27/29 South Lambeth Rd., London SW8 1SZ.

Society Visit

A visit to the British Aerospace site at Stevenage in Herts. will take place on **17 April 1984**. See the inside front cover of this issue for details.

History Meeting

Theme: **BRITISH ROCKETRY DURING THE SECOND WORLD WAR**

A number of contributions will be presented at a meeting on the above topic, which has been arranged by the Society's History Sub-committee. To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **2 May 1984,** 6.30–9.00 p.m.

Admission is by ticket only. A registration fee of £1.00 is payable, which will also cover the cost of coffee. Members should apply in good time enclosing a stamped addressed envelope.

LIBRARY

The Library will be open to members from 5.30–7.00 p.m. on the following dates:

30 Nov. and 7 Dec. 1983

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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